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THE CHEMIST IN TIMES OF CRISES[1]

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American chemists have played a large role in the development of industrial America. They have given us many new products. In the field of textiles, for example, they have produced rayon, nylon and, more recently, orlon and amilon. They have given us new metals which have such strength and durability that engines for our cars are sturdier and longer lived. They have given us many products which have contributed to the better health of mankind—I refer to vitamins, sulfa drugs, penicillin, streptomycin and other antibiotics. They have given us all kinds of plastics and synthetic resins.

Because of the great growth of chemical industry in America, we have become less dependent on chemical imports. In 1900 most of the chemicals needed for American industry came from Europe. For example, over 90% of the dyes we needed came from Germany and England; today we import less than 5%. During World War I we found methods for making large quantities of such basic organic chemicals as benzene, alcohol, phenol, and nitrocellulose. At that time also, we were faced with a great shortage of potassium salts, or potash. We had been obtaining it from the Strassfurt mines of Germany but that supply was no longer available. As a result, we set about finding sources of potassium at home. Strenuous efforts produced only 50,000 tons of potash in 1918, but by 1944, 800,000 tons were produced annually. The remarkable increase was due in part to the development of a method of recovering potassium chloride from Searles Lake in California, but mainly to the discovery of a new source in New Mexico and Texas. Here, a vast salt deposit covers

[1] Recently given as a broadcast over WKZO, Kalamazoo, Michigan.

more than 40,000 square miles from Texas to Kansas; it was laid down by the drying up of a sea over 200 million years ago. Because of stimulation of the war effort, by 1930 the American chemical industry was doing an annual business of well over a billion dollars. The growth of this industry has continued; the 1950 production may well have exceeded ten billion dollars.

During World War II, we no longer had a shortage of potassium but we did have shortages of magnesium, tin, aluminum, rubber, and other critical materials. Prior to 1940 the main producer of magnesium in the U. S. was the Dow Chemical Company. The brines from wells around Midland, Michigan contained magnesium bromide. By electrolysis—a method of passing a direct electric current through the molten salt—magnesium was separated from the bromine. To meet the World War II needs the Dow Chemical Company developed at Freeport, Texas a large scale plant for taking magnesium from sea water. Still other methods of recovering magnesium from dolomite, a natural occurring mineral, were developed. Today we no longer need fear a shortage of magnesium in spite of the fact that much is used in aircraft construction. For example, the Boeing B-47 is being modified to substitute large quantities of magnesium sheet for aluminum sheet. The new C-124 uses about 1,000 lbs. of magnesium alloy I-beams.

You are all familiar with the method used to solve the shortage of natural rubber. Through cooperation with industry the government sponsored a synthetic rubber program. By 1945 the American chemical industry was geared to a maximum annual production of 1,000,000 tons of synthetic rubber. The G.R.S. rubber was made mainly from butadiene obtained from petroleum and from styrene obtained from coal tar.

With the close of the War in 1945 the government cut back the production of synthetic rubber and gradually returned to the use of again available natural rubber. The present crisis has brought another change. Recently the Office of Defense Man Power reported a large jump in synthetic rubber production from an annual rate of 335,000 tons one year ago, to well over 500,000 tons at the beginning of the current year. By June of this year it is estimated that synthetic rubber production will obtain a rate of over 900,000 long tons per year. In case of an emergency such as we faced right after Pearl Harbor, we no longer need fear a shortage of rubber tires, thanks to the American chemical industry.

At the present time we are faced with certain shortages in raw materials. Some of the present critical materials are aluminum, tungsten, tin, cobalt, manganese, cadmium, sulfur, nickel and copper. There is also a great shortage of the organic liquids benzene and ethyl alcohol.

Chemical "know how" is not always sufficient to solve a given prob-

lem. For example, we cannot produce manganese, an element needed as an alloy to harden and toughen steel, if we lack a source of the manganese ore. Since only relatively small amounts are found in this country, we are forced to import over a million tons annually from Russia, India, and Brazil. Within the past years research has been carried out in an effort to recover manganese from very low grade pyrolusite ores found here in America.

Of the more than ninety known elements, the majority are necessary for the needed products of modern civilization. To be sure, the elements are all found in the earth's crust but nature has through the ages, as a result of the workings of natural law, concentrated certain elements at certain locations on this globe. For example, iron ore was concentrated in the Lake Superior region. Beds of much needed phosphate rocks are found in Georgia, Florida and Montana. But such elements as tin, tungsten, and manganese have been concentrated in geographic sites located at a great distance from us. In such cases the only solution is to create stock piles in times of peace. The U. S. Government has been doing just that. The Munitions Board has at present a strategic materials stock pile goal which when completed will cost U. S. taxpayers four billion dollars. By next July they hope to have this stock pile within 75% of completion. In addition the National Production Authority has ordered cutbacks in civilian use of the following metals—aluminum, cadmium, cobalt, copper, tin, nickel and tungsten.

These restrictions may have some bearing on our everyday lives. In order to meet a 10% cut in the use of tin for tin cans a leading producer of metal containers is plating the inside surface to normal thickness but is plating the outside of the can with a much thinner layer. Previous practice was to coat both sides with an equal weight of tin.

Mr. C. L. McCuen of General Motors Research Laboratories Division[2] recently gave the following information concerning the use of certain metals in the manufacture of a 1950 four door sedan of approximately 3,800 lbs. weight. It would require copper 26 lbs., copper alloys 15.61 lbs., chromium 6.06 lbs., manganese 18.82 lbs., nickel 1.06 lbs., tin 1.37 lbs., along with 2,500 lbs. of steel and given weights of other metals. Since there is a shortage of steel and since there have been cutbacks in the use of nickel, copper and tin, two things will probably happen. First, there will be a cutback in the number of cars manufactured and, second, those made will have less trim.

Among the non-metals the most acute shortage is the production

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[2] Talk given by C. L. McCuen, General Motors Vice President and General Manager of General Motors Research Laboratories, before the Commercial Chemical Development Association and the Chemical Market Research Association at Washington, D. C. in October 1950.

of sulfur. For the past thirty years the majority of our sulfur has come from subterranean brimstone deposits located in Texas and Louisiana. At a depth of 500 to 1,500 feet under beds of clay, quicksand, and rock it was once considered a worthless resource. At the close of the last century an engineer, Herman Frasch, worked out a method of passing super heated steam down into the ground through the outside pipe of three concentric pipes, thus melting the sulfur. Later compressed air was forced down through the inner pipe and sulfur was finally forced to the top through the middle pipe. The product obtained was over 99% pure. This source met not only our needs but also that of Britain, Canada and other countries. The rich Gulf coast deposits are beginning to run out and the demand for sulfur is 150% of that of the peak war years. Sulfur and sulfuric acid, which is made directly from oxides of sulfur, are needed in practically every chemical industry from petroleum to steel, to paper, to fertilizer, to explosives etc. Farmers are worried since 35% of all sulfur used in the U. S. goes indirectly into fertilizer. Iron pyrite (FeS_2) and other sulfides are fairly abundant. It seems probable that the only solution to this shortage of sulfur is to develop methods for recovery from these sources. Sulfur obtained from pyrites will probably be more expensive.

In conclusion I want to make a few brief statements concerning research in the field of liquid fuels.

Petroleum is one of our most valuable minerals. It is very much needed in times of both peace and war. We derive 30% of our energy from oil. Each day there is used in the United States 6 million barrels[3] of crude oil. This is a total of over 2 billion barrels annually. The use of petroleum has quadrupled in the past twenty-five years. The majority of all locomotives now being built are oil-burning diesels.

Petroleum products contributed much to the winning of World War II. They furnished fuel and lubrication for our mechanized units. Napoleon once said that armies fight on their stomachs; meaning of course, that fighting men must be well fed. Modern armies fight on wheels motivated by gasoline and lubricated by oil. Petroleum also furnished quantities of 100 octane gasoline which gave our air force a real advantage over their foes who did well to get 86 octane gasoline. It furnished much of the toluene used to make the T.N.T. for block busters.

What would we do in case of another world war, when we might suddenly have a 30 to 50% increase in demand for gasoline, butadiene, toluene and other products? Our Congress was concerned

[3] A barrel of oil is 42 gallons.

with this problem when in 1944 they passed the Synthetic Fuels Act. As a result of that act the Bureau of Mines put 200 scientists working on a 30 million dollar program of research in the production of liquid fuels from coal, natural gas and oil shale. That work is being continued at the present time. At Brucetown, Pennsylvania and at Louisiana, Missouri, the Bureau of Mines has set up laboratories and pilot plants for a careful study of methods for converting natural gas and coal into liquid fuels.

In Wyoming, Montana and Utah are found great beds of oil-bearing shale. The Bureau of Mines has located a demonstration plant at Rifle, Colorado and a research laboratory at Laramie, Wyoming for the purpose of investigating methods of obtaining oil from shale. At Rifle, Colorado the shale is blasted from cliffs and crushed. It is then heated in retorts to drive off the oil. One ton of good Colorado shale will produce approximately 40 gallons of oil.

In this talk we have observed how the American chemists have developed a ten-billion-dollar-a-year industry which helps to make our nation strong in times of crises. The making of H-bombs has not been mentioned. However, if such bombs become a reality, the chemists will have to make their contributions as they did in the development of the A-bomb. We only hope the danger of an immediate world war will pass and that the chemists of America may be permitted to work on peace time problems.

THE "MATCH HEAD" CARTESIAN DIVER

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Probably no group of men is more generally aware of and concerned with the problems that may arise in connection with buoyancy than the men who go to sea in submarines. It was from the members of the crew of one of these boats that I learned a particularly simple and effective demonstration of the classical experiment called the Cartesian Diver.

An ordinary, small-mouthed, clear glass bottle is filled to the top with water. Then the head of a match is broken off and dropped into the bottle. The thumb is placed over the top and pressure is applied. The match head will sink or rise as the pressure is increased or diminished. A little experimentation will indicate just how much of the "stick" to leave on the match head to keep the necessary force within the strength of the operator. This motion is quite sensitive and with a little care the match head may be made to rise, sink, or remain suspended, at the will of the operator.

I have tried this little experiment with all sorts of match heads and it would seem that whether they be "safety" or "strike anywhere," whether they have wooden or paper "sticks," makes little difference.

This demonstration works because the wood (or paper) which is attached to the match head is somewhat porous and the changes in pressure result in changes in volume and hence in buoyancy.

TEACHING MINERALOGY IN JUNIOR HIGH SCHOOLS

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Experiences in teaching mineralogy to students in the eighth grade in Stratford Junior High School, in Arlington, Virginia, have convinced this writer that junior high school science can and should include the study of minerals.

Adolescents are very much concerned with exploring the field of science in order to find where they fit into the scheme of things, and mineral products are becoming more and more prominent in their minds as factors which determine their welfare now and promise to become even more important in the future. Boy Scouts have long included minerals in their list of merit badges.

Foresters, agriculturists, and mining engineers are finding that a study of the geology and mineralogy of any area will reveal a close connection between vegetation and the rocks underlying it.

Fission of uranium and fusion of hydrogen and possible fission of other elements with resultant production of energy have created an almost insatiable desire among youngsters to learn about the minerals from which fissionable materials can be obtained.

During the past few years mineralogical societies have sprung up all over the United States, and soon we will have a national federation of mineralogists. Many of these organizations admit interested children to membership regardless of age.

Adolescents have a deep curiosity concerning gem stones and precious minerals, and their questions about these matters are rarely answered fully or satisfactorily.

The relative scarcity of minerals in accessible locations and appreciable quantities has heightened the necessity of locating more and more sources of minerals necessary to our present standard of living. World Wars I and II, and the Korean conflict, have pointed up the inconveniences brought about by the inability to be self-sustaining from a mineralogical standpoint during wartime.

All these factors have served to bring mineralogy to a prominent position in the interests of youngsters in the junior high school, and this writer believes the science teacher should manage adequately to answer this demand for accurate, useful knowledge.

Conversation with another science teacher in Arlington County brought forth the fact that many students in the county were interested in studying mineralogy. At that time no one had attempted to teach a unit of this kind, and resource units prepared the preceding

year did not include a unit in mineralogy. The decision was made to place mineralogy before pupils in the eighth grade to determine whether they can and will learn about minerals. That they can, will, and do learn about minerals has been irrevocably proved.

The unit taught this year included information on limestone, dolomite, shale, sandstone, and conglomerate as representative of sedimentary rocks; diabase, rhyolite, lava, granite, and obsidian as igneous rocks; and marble, chlorite schists, granite gneisses, and slate were studied as metamorphic rocks. Specimens of each rock were on hand for examination. It soon became apparent that the teacher needs at least one sample of each rock per student. The pupil needs to feel, see, lift, drop, scratch, and attempt to break the rock.

Acid tests for marble and limestone help to arouse interest and curiosity. The carbon dioxide can be piped into lime water to prove the presence of limestone, and the white precipitate can be dissolved later by adding acid. This experiment appeals to the chemical show enthusiasts who are always looking for new tricks for their shows.

Inevitably, during the study of granite, quartz will come into the discussion; calcite will crop up during a study of limestone and marble; and fool's gold will appear in some of the granite, gneiss, schist or diabase. Specimens of these minerals are quite interesting and are relatively easy to acquire. The collection in use contained these minerals plus selenite, a form of gypsum.

These minerals were studied in detail to illustrate the various means of identifying minerals and to teach identification of the minerals studied. Characteristics which may be illustrated by these minerals include hardness, luster, color, sectility, flexibility, streak, transmission of light, and the acid test. It was believed that crystal systems and specific gravity were too complicated for the understanding of eighth graders; so no attempt was made to teach these concepts, except that samples of crystals were used to illustrate typical forms and pasteboard models of crystals were displayed.

Display cases of minerals were studiously avoided in an effort to get away from the technique of giving students science under glass where they cannot examine it carefully. A display case of fine specimens in a central location is being planned for next year. This case will be used as a means of motivation and not as a teaching device.

Some attempt was made to answer all questions on precious stones, but time and the lack of adequate specimens limited this study area. It is believed that study should be done on diamond, emerald, topaz, sapphire, ruby, garnet, and turquoise, and others of local interest or importance.

Samples of all the minerals in the hardness scale were not available. Plans for next year include enough hardness boxes to furnish each

student with hardness samples running from one through nine.

Few minerals have a hardness of more than seven so streak plates made of flooring tiles were used. They are eminently satisfactory.

Not enough space was available to do proper justice to the study. A great deal of storeroom space is required. Open top boxes with partitions to separate varieties of minerals are quite useful. Each mineral should be kept under the proper label to facilitate location.

Reading glasses, tripod microscopes, and other glasses of twenty powers were quite helpful in the study of small and intricate specimens. Binocular microscopes were found to be irreplaceable in the study of microscopic crystals. The opaque minerals could not be seen under the monocular microscope that depends on light reflected through a slide.

Magnets proved to be handy tools to have around, as the identification of many of the specimens brought in by pupils depended on their attraction to magnets or the failure of magnets to attract them.

Glass, iron, knives, and copper coins were tested in the classroom to establish their hardness so that they could be used to test hardness in the field.

Materials collected by this writer over a period of six years were used for the unit. When professional and amateur mineralogists in the area learned that the course was being taught, offers of mineral samples came fast and thick and helpful publications suddenly became available for use.

Technical terms and names which showed any promise of getting between the teacher and the pupils were avoided. New and necessary names and terms were subjected to spelling and pronunciation practice. Experiments with more than one mineral on a specimen indicate that pupils can study only one mineral at a time. More than one new name and set of characteristics at a time confuses pupils when presented before each mineral has been studied separately. Contrast of the characteristics of minerals and steady reference to the hardness table was found to be helpful.

To the knowledge of this writer, this was the first attempt to teach mineralogy in the junior high school in Arlington County. It was successful as a beginning step toward filling a need felt by adolescents. It could have been better with more materials, more space, and adequate reference books. It will be better next year.

BEADS FOR YOUR ABACUS

Prof. F. Hawthorne, Hofstra College, Hempstead, N. Y., has some extra beads for making the abacus described on page 227 of our March 1951 issue. He will be glad to supply anyone sending shipping cost "while they last." Write today; the supply is limited.

IS THE WEIGHT OF IRON AFFECTED BY MAGNETIZATION?

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There have been two distinct schools of thought regarding the magnetizing processes which go on in a body, particularly a ferromagnetic body. The older and nearly extinct school visualized the process as a flow of material particles within the body being magnetized. Our magnetic vocabulary is influenced by this idea. To this day we use the term magnetic flux, but it started with the concept just mentioned that something flowed in a body when it was magnetized. The adherents to this school were kineticists and formed the predominant school for more than a century. It has been outstanding for its sterility in creative ideas for the advancement of the theories of magnetism.

The second and newer school of thought believed that the magnetizing processes were brought about by the rotation of material particles within the body magnetized. This was elaborated to the point where these rotating particles were dipoles which were brought into alignment with the magnetizing field and that these dipoles rotated against their own mutual restraints. These restraints set up strains within the medium and so magnetic energy was conceived as being potential energy. The idea of something flowing had no part in the thoughts of this school.

To this school may be ascribed the discovery of the gyromagnetic effect and the developments which have arisen from this discovery. This effect is the most creative and stimulating discovery which has come to electromagnetism since Oersted's discovery in 1820—that magnetism was due to electricity in motion.

The idea of the kineticists, that something flowed when a body was magnetized, naturally led in earlier days to the concept that these material particles which flowed into or out of the body would increase or decrease its weight in the process of being magnetized. Writers and investigators have spoken of this matter repeatedly since the days of Dr. Gilbert (300 years ago) who maintained that the process of magnetization did not change the weight of a body.

Tiberius Cavallo[1] gave a summary of the knowledge extant 150 years ago on this interesting question of change in weight with magnetization. In a footnote appears the following: "Gassendus, Mersennus, and Gilbert, maintain that the weight of needles is not altered by being made magnetic. Mr. Whiston says he found, 'by accurate

[1] Cavallo, Tiberius, "A Treatise on Magnetism in Theory and Practice," page 75, 3rd Ed., 1800.

experiments, that a piece of steel, weighing 4584.125 grains, lost 2.25 grains; and another, which weighed 65726 grains, lost 14 grains by being made magnetic.' With other persons, magnetism seems to have increased the weight of steel. But it is very probable, that the vicinity of iron, or of some other ferruginous body, might have had some action on the magnetic steel when it was weighed."

In 1907–1909 several articles appeared on the subject as to whether mass or weight was affected by the process of magnetization. The first article was by Director L. A. Bauer[2] of the Department of Terrestrial Magnetism, Carnegie Institution of Washington, who raised the question as to whether the earth's action on a magnet was only that of a couple. He gave data to show that it was not and that the weight of a magnet was affected by the process of magnetization. Bauer carried several magnets and a non-magnetic balance to the far distant parts of the earth and showed by his data that the weight was changed. This was answered shortly thereafter by Lloyd[3] who scouted the idea that magnetization could affect the weight of a magnetized piece of steel. Lloyd argued—"It is obvious that if there be local disturbances of the field, the weighings may give different results for different positions of the magnet, since it is not simply the force of gravitation which is being measured, but in addition the magnetic forces which act upon the bar. Such a specimen is well suited to the purpose of determining whether the magnetic forces have any translational resultant (and this was the primary object of the experiments undertaken by Dr. Bauer), but it is very ill suited to the purpose of determining whether the gravitational force alone is constant. For this purpose it is desirable to have the specimen forming a closed magnetic circuit, and hence without poles, so that there will be no action upon it by the earth's field."

In other words, Lloyd weighed a toroid electromagnet, with and without an electric current flowing through the coil, and was not able to detect any variation in weight due to its magnetization.

Bauer replied to this by saying—"The ring magnet, shorn of its external lines of force, lacks, in consequence, some of the characteristics and properties of a complete (bar) magnet." Bauer was particularly interested in the behavior of a bar magnet when immersed in the terrestrial magnetic field. This interest followed from his use of magnetic needles in making many of the observations connected with the earth's magnetic field. Bauer did not fail, however, to point out that the measurements made by Lloyd were important in the general discussion.

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[2] Bauer, L. A., *Terr. Mag. and Atmos. Elec.*, Vol. 13, p. 25, 1908; *Terr. Mag. and Atmos. Elec.*, Vol. 14, p. 72, 1909.

[3] Lloyd, M. G., *Terr. Mag. and Atmos. Elec.*, Vol. 14, p. 67, 1909.

In reviewing Lloyd's work Bauer took occasion to give some results which Dr. Charles Walker, then Professor of Chemistry in the South Carolina Military Academy, had obtained by weighing a magnet in various positions on the balance pan. Walker's observations supported Bauer's work that magnetization did affect the weight of the steel magnet. In closing his letter, which Bauer quoted, Walker makes the following significant statement: "On the other hand if the earth's field is eliminated, the results could only be explained on the assumption of the mutual action of magnetic and gravitational lines of force."

For over forty years now no one has seemed to consider this problem of any interest and there the matter has stood, just where Bauer and other workers left it—with no definite answer. In none of these investigations has anything been said specifically about magnetic field gradients, to say nothing about introducing such gradients into the space where the magnet was being weighed to see what a magnetic field gradient would do to the apparent weight of the magnet. In a perfectly uniform magnetic field, theory shows that no force of translation is imparted to a bar magnet.

In the late winter of 1949–1950 an Alnico magnet was weighed in a room on the second floor of the Physics Laboratory at Amherst College. A fine, so-called non-magnetic, balance was used in the weighing. This balance was placed on a rotating table so that the axis of rotation of the table passed along the axis of the magnet as it sat in a vertical position in the center of the balance pan.

No matter how the balance was rotated with the turn table the Alnico magnet, weighing about 100 grams, always showed an apparent increase in weight when the north pole of the magnet was on top and a decrease when the south magnetic pole was up. This not only accounts for the reason why some investigators found an increase and others a decrease in weight due to magnetization, but it also pointed suspiciously to field gradients as operating on the magnet. However, the field gradient was not in the direction in which one would expect the gradient of the earth's field to work, if the north magnetic pôle of the earth is a negative or south pole as we know it to be. Furthermore, we have always considered the earth's magnetic field to be so uniform that we did not expect it to put a force of translation onto a bar magnet. What other field gradients could be expected to operate on the magnet being weighed?

That field gradients are set up in a laboratory was beautifully demonstrated by an experience the author had while teaching at Oberlin College. For about 10 years there had been a definite station in the laboratory where the earth's magnetic field strength was measured annually, the value of which showed a persistent constancy through the years. Then the State came along and ordered the college to put

steel fire escapes on all buildings where students congregated. The upper end of one of these steel stairways ran within about 3 meters of the station for observing the earth's field. The first time the earth's field intensity was measured after the installation of the steel stairways it was found that the intensity had increased three-fold. After repeating the experiment several times and realizing that something had happened around the laboratory, investigation revealed that the upper end of the steel stairway was a powerful south-seeking magnetic pole with a north pole at the bottom. The steel stairway was almost directly parallel to the earth's magnetic field, dip and all. With such magnetic poles so close to the station (3 meters) and the steel steps with their frame work nearly 5 meters long, it is perfectly evident that not only had the magnetic field intensity at the station been materially altered, but a large field gradient introduced. This sort of affairs must occur in most laboratories where steel steam pipes are installed and other large bulks of iron pile up with the years in a laboratory.

What is a magnetic field gradient? In Fig. 1 is shown the magnetic field which lies about a N-pole of a magnet and it may also represent

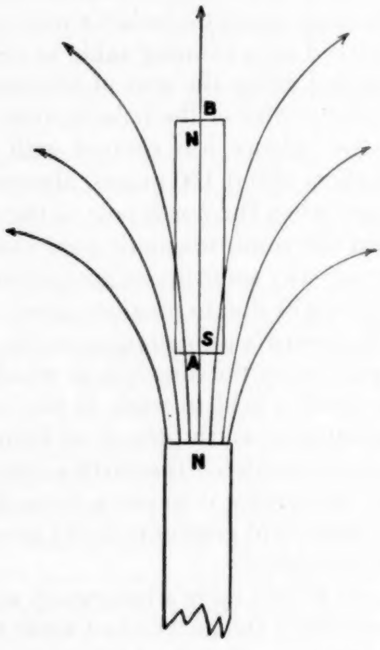

FIG. 1. In a field gradient the magnet, $N-S$, has a force of translation acting on it.

the field of the magnet in which the electromagnet is later weighed

and whose values are given in Table I. Out of the N-pole of the magnet in Fig. 1 we picture the magnetic lines of force to emerge and spread out into space to reconverge again at the S-pole. For a given magnet there is a definite number of these magnetic lines of force emerging from the N-pole and the number per square centimeter measures the field intensity. Inasmuch as the lines of force diverge as they leave the pole, the number of lines of force per unit area must grow less and less the farther one gets away from the N-pole. Let H_2 represent the field intensity at A and H_1 at B, wherein H_2 is greater than H_1. If the distance between A and B is d cm, then $(H_2-H_1)/d$ will be the value of the gradient. The field intensity is measured in oersteds, hence the gradient $(H_2-H_1)/d$ = oersteds per centimeter.

Let us suppose a magnet whose distance between poles is l cm is hung on the arm of a balance beam, so that the N-pole is at B and the S-pole is at A, then the N-pole producing the magnetic field, of which A and B are two points in it, will pull the S-pole of the suspended magnet with a force greater than it repels the N-pole of the suspended magnet. As a result the magnet, $S-N$, is pulled downward toward the N-pole and the suspended magnet will appear to weigh more when magnetized than when unmagnetized. If the N-pole of the fixed magnet is replaced by a S-pole then the suspended magnet will be urged in the other direction and will appear to weigh less when magnetized than when unmagnetized. It is this non-uniformity or gradient in the magnetic field which gives rise to a linear translation of the entire magnet and if the axis of the magnet makes an angle θ with the direction of the field then a torque is also applied to the suspended magnet and both rotation and translation may occur.

Let G be the gradient of the field, then the force with which the big magnet pulls the suspended magnet will be,

$$F = MG$$

where M is the magnetic moment of the suspended magnet and where

$$M = ml$$

m being the pole strength of the suspended magnet and l the distance between the two poles. mH_2 is the force on the N-pole of the suspended magnet and mH_1 the force on the S-pole. The total force is

$$\begin{aligned} F &= m(H_2 - H_1) = m(H_1 + lG - H_1) \\ &= mlG \\ &= MG. \end{aligned}$$

With a properly wound coil it should be possible to obtain a magnetic field with a uniform gradient over a considerable length of the

coil. Such a coil would be a splendid addition to the equipment of a magnetic laboratory in which to determine the magnetic moment of a magnet or of a coil.

With no equipment at our disposal with which to counteract the earth's magnetic field and the field gradients which existed, it was natural to turn to a magnetic laboratory where these phases of the earth's magnetic field are under control.

At the Magnetic Laboratory of the General Motors Research Laboratories there are large Helmholtz coils (the largest one is nine feet in diameter) for obtaining fairly large volumes where the earth's magnetic field intensity may be reduced to less than 2 gamma, (1 gamma $=10^{-5}$ oersted) and where the three components, vertical, $N-S$, and the $E-W$, mutually at right angles to each other, may be continually kept at practically zero value for all variations which may occur, unless a magnetic storm should spring up and then one doesn't take readings. Furthermore this magnetic laboratory was built without ferromagnetic materials going into its construction and so there was freedom from gradients to any field which might exist in the laboratory.

This set-up seemed like an ideal one for testing out whether the earth's magnetic field action on a bar magnet is only a couple or does it tend to give it translation as well? Within moderate distances of each other two magnets do react on each other to push themselves apart, or to pull themselves toward each other. Does the earth as a magnet attract or repel an ordinary bar magnet, or do we look for magnetic gradients due to other causes, or as Walker said,—is there a "mutual action of magnetic and gravitational lines of force?" In weighing a bar magnet with the earth's magnetic field completely annulled, it would also be very easy to introduce a magnetic field gradient by placing another small magnet in the vicinity of the bar magnet being weighed and see how such a gradient would affect the apparent weight of the magnet weighed.

This was the experiment actually carried out and it was shown that when the earth's field and other disturbing magnetic gradients were completely eliminated, there was no difference which could be detected in the weight of the magnet when one end or the other was in the "up" position when being weighed. Furthermore, when a short magnet was placed end-on at a distance of a few feet below the magnet being weighed a magnetic gradient was introduced as in Fig. 1, and this made a difference in the apparent weight of the magnet. Reversing the direction of the magnetic action of the auxiliary magnet, also reversed the direction of the swing of the balance beam on which the magnet was weighed.

In detail, the experiment was carried out in the following manner.

A special short-armed balance, Fig. 2, was built which could be placed in the experimental chamber, shown in Fig. 3, and located at the center of the Helmholtz coils. See Fig. 4. On top of the balance beam was attached a finely figured spherical mirror ground to a radius to give a clean cut image of a cross-wire at a distance of about 16 meters. This optical lever gave great sensitivity to readings of the deflections of the balance beam. Instead of weighing a permanent magnet, a bar electromagnet was used so that without disturbing its position it could be weighed when magnetized upward or when reversed. It would have an external field similar to a bar magnet. This electro-

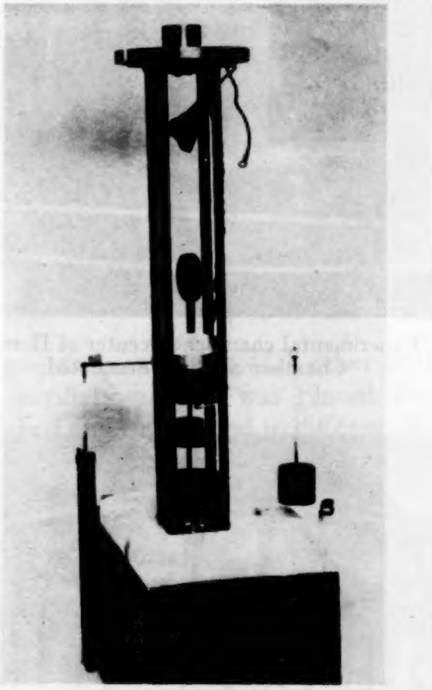

FIG. 2. Balance used in testing effect of magnetic field gradients in changing apparent weight of iron magnets.

magnet consisted of a soft iron core, 14.3 cm. long and 0.94 cm. in diameter. Over this iron rod as a core were wound 15,763 turns of No. 41 copper wire coated with formex insulation. The total effective area of the coil was $\Sigma A = 13{,}992$ cm.^{2}. A flux density of 8,000 gausses was estimated for the electromagnet when a current of 50 milliamperes flowed in the coil. The iron was of the purest form obtainable. The leads for carrying the current to the coil were of such fine wire that they added no appreciable torque in getting the deflections of the balance beam. A brass cylinder, *B*, Fig. 2, served as a counter

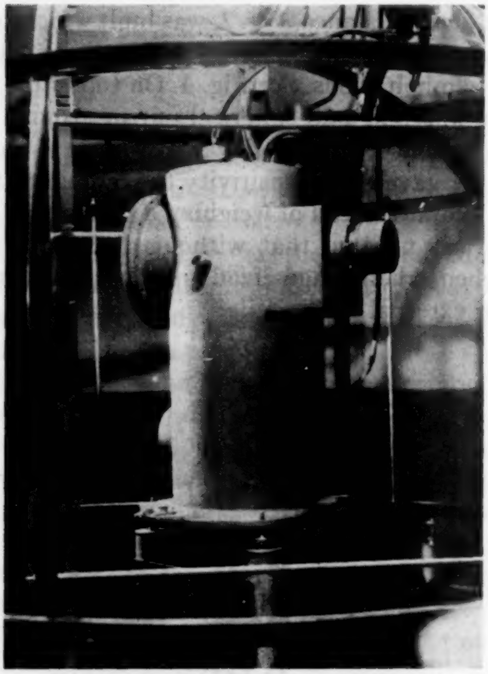

FIG. 3. Experimental chamber at center of Helmholtz coils. Chamber could be evacuated.

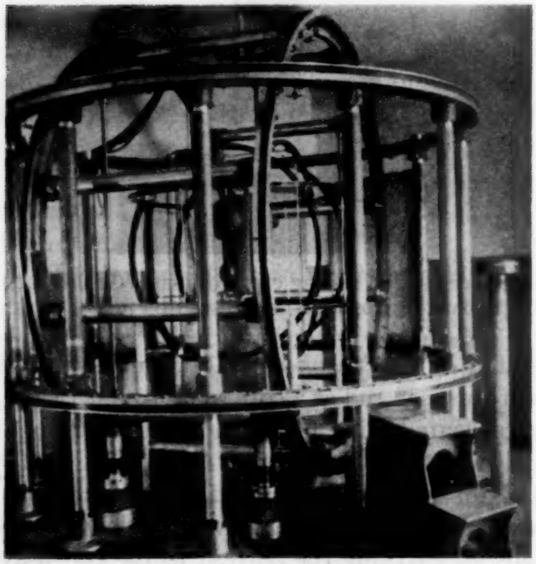

FIG. 4. Helmholtz coils used in annulling the various components of the earth's magnetic field.

weight for the electromagnet. Everything about the balance was non-magnetic and the central knife edge was agate, oscillating on agate plates. It was a sensitive short-armed balance, built especially for the purpose to which it was put. The sensitivity of the balance, when the electromagnet was attached, was such that when a mass of 5 milligrams was added to the brass counter poise a deflection of 30 millimeters occurred, or a sensitivity of 0.167 mg. per millimeter. Inasmuch as one could easily read to 0.2 of a millimeter on the scale one could, therefore, easily detect any change in the apparent mass of the electromagnet equal to one part in three million, since its mass was about 100 grams. There was absolutely no indication of a change in weight of the electromagnet when all inhomogeneous magnetic fields had been eliminated, but the presence of a magnet 5 cm. long and at a distance of about 120 cm. gave a deflection of 3.44 mm. which means a difference in apparent weight of 0.0055 gm. in a total weight of 100 grams.

The pull of one magnet on another follows the inverse 4th power law with respect to the distance d between the centers of the two magnets considered.

$$F = 6MM'/d^4$$

when the two magnets are end on to each other as they were in this experiment. The auxiliary magnet was placed directly under the magnet being weighed and then raised to different distances between their centers. In the foregoing equation M and M' are the magnetic moments of the two magnets, which for any one weighing were constant. Hence it follows that the product $F \times d^4 =$ a constant. This is demonstrated in the following table.

TABLE I

F	d^4	$F \times d^4$
2.56	1	2.56
.822	2.829	2.33
.438	5.226	2.29
.198	11.44	2.27
.134	17.83	2.39
		Ave. 2.37

One must conclude, therefore, that all observations which have shown a difference in weight between magnetized and unmagnetized iron were carried out in a place where magnetic field gradients of one kind or another existed.

If one is to look for a relation between magnetic and gravitational

forces as suggested by Walker, they will have to increase the sensitivity of their equipment far beyond that described in this paper.

The author is under great obligations to Mr. G. G. Scott of the General Motors Research Laboratories for help in designing the balance and the electromagnet and for many helpful discussions. To the Executive Staff of the General Motors Research Laboratories he is also most grateful for the beautiful equipment placed at his disposal. Without the big Helmholtz coils and the long optical lever it would not have been possible to have answered these questions so definitely.

THE NATION'S SCHOOL HEADACHE

America's No. 1 school headache is its lack of adequate schoolhouses, a committee of citizens from 29 national organizations emphasized in a special report entitled "Citizens Look At Our Schoolhouses" just released by the Office of Education, Federal Security Agency.

The report, presenting information on what has happened to our schools during the past 25 years, and reviewing current and anticipated schoolhousing problems, was made public by Earl James McGrath, Commissioner of Education.

"Coming from laymen on the Citizens Federal Committee on Education, an advisory group to the Office of Education, this progress report offers factual evidence of the Nation's critical need for schoolhouse construction," Commissioner McGrath said today. "Facts contained in the report should impress citizens with many of the problems school administrators face at this time in helping meet the urgent needs of our children. The report also focuses upon schoolhousing needs of the next decade which our country's growing population will dictate."

The report tells briefly "what happened to our schools during the past quarter of a century," and reveals that "we will need at least 50 per cent more classrooms over the next 10 years than we now have" to take care of the rapidly-increasing school population. "By 1959–60," the report says, "270,000 new classrooms will be needed for increased enrollments in grades 1–12, 150,000 for necessary replacements, 60,000 for reorganized school districts, and 40,000 for kindergartens and grades 13 and 14."

The total cost of this number of needed classrooms, according to the report, will be $14,040,000,000, an expenditure which is termed "an investment in America."

"One out of five schoolhouses now in use throughout the country should be abandoned or extensively remodeled," the report points out. Many of these "are admittedly firetraps." A large number lack normal sanitary conveniences, with no inside toilets or decent washrooms. Many others, some dating back to the Civil War, "are not adapted to modern educational demands or administrative efficiency." Poor location of still other schools, because of shifting population trends, results in high pupil transportation costs and other administrative problems, the report reveals.

Copies of the report, "Citizens Look At Our Schoolhouses," are available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Single copies are 15 cents each. A discount of 25 per cent is allowed on orders for 100 copies or more.

THE PREVALENCE OF MATHEMATICS IN SCIENCE FROM 1900 TO 1950

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There is talk now among certain chemists that chemistry is rapidly becoming a mathematical subject. Some time ago a laboratory instructor of the author's expressed the opinion that in ten years organic chemistry would be mathematical. The years have nearly passed but I doubt that the prediction as he meant it is by any means true. Theoretical chemistry, on the other hand, must be mathematical by its very nature, and certainly quantum mechanics finds its place there as inevitably as it does in the fields more properly called physics. Biology, too, is not without its mathematical beginnings. Last year from a public platform, one of the prominent biochemists from Columbia University declared that biology has not yet become a science. He was referring to the descriptive nature of the subject and its lack of a background of theory such as is possessed by physics and chemistry. Of course he would consider biophysics and biochemistry to be sciences. Many consider these fields to be aspects of biology.

While contemplating the increasingly mathematical nature of chemistry and biology, the author began to wonder how well these changes could be substantiated by objective data and whether even physics could be getting more mathematical. It seemed that evidence one way or the other might well be found in scientific periodicals which were considered authentic in their respective fields. The *Physical Review* was selected as the authoritative periodical of physics and the *Journal of the American Chemical Society* as authoritative for chemistry. In each case examinations were made of issues for 1900 and the decade years thereafter up to 1950.

Articles in the *Physical Review* were first studied to determine how many contained mathematical expressions (usually equations) and how many did not. Mere quantitative data and tables were not considered, as numerical information of this sort can be understood without any special knowledge of mathematics on the part of the reader.

For each decade year 20 articles were included. These consisted of the first 10 articles in the volume for that year plus the last 10 articles of the first six months of the year. In the more recent issues the articles occurred, therefore, in the January and June numbers. In the earlier years there were less than 10 articles each month and more than one month had to be used for each group. A few articles devoted entirely to biography were omitted. The results are presented in Table I from which it can be seen that physics has not changed sig-

nificantly in 50 years with regard to the number of articles in which no mathematics appears. When the figures of Table I are separated as to the January and the June groups there is no important difference. The data of Table I represent a total of 120 articles. The same

TABLE I. ANALYSIS OF THE *Physical Review*

Year	Number of articles out of 20 which are without mathematical equations
1900	8
1910	7
1920	6
1930	6
1940	8
1950	5

120 articles were examined to determine whether it was necessary to understand the mathematics in order to get a reasonably good understanding of the article. Such judgments were admittedly subjective. The present author felt that in most cases where present the mathematics had to be understood in order to understand the article.

The 120 articles were further analyzed to determine whether the reader could get along with a knowledge of algebra and trigonometry only or whether calculus or higher mathematics was required. These results are presented in Table II. A Chi Square test applied to this table showed that a hypothesis concerning an increase in mathematical level with time is definitely without support. An apparent

TABLE II. ANALYSIS OF THE *Physical Review*

Year	Number of articles using only algebra & trigonometry	Number of articles using calculus or higher mathematics	Total
1900	3	7	10
1910	11	1	12
1920	4	9	13
1930	7	4	11
1940	5	7	12
1950	1	12	13
	31	40	71

discrepancy between some figures in Table I and Table II is explained by the few articles in which the author thought the mathematics which was present might be skipped without too much loss in understanding.

A more detailed study was made of the first 10 articles of 1900 and

1950. The number of lines of print in each of these articles was counted as well as the number of lines devoted to mathematics. Titles, captions, and footnotes were not included in this count. The percentage of lines of mathematics to total lines of print was determined for each article and found to vary tremendously from article to article but not noticeably between 1900 and 1950.

In summary it may be said that for physics there is no evidence of change in the prevalence of mathematics in research articles during the first half of the Twentieth Century. The only change which the author could detect was in the use of newer methods connected with quantum mechanics. This change was to be expected in view of the fact that the quantum mechanics was not introduced until the second quarter of the century.

Articles from the *Journal of the American Chemical Society* were examined to determine the percentage containing mathematical equations. Purely chemical equations and equations for ionization constants in terms of concentrations or active masses were omitted. The data are presented in Table III. The year 1949 was substituted for 1950 to avoid delay in waiting for the magazines to return from the bindery. All articles in the months specified were included. There

TABLE III. ANALYSIS OF *Journal of the American Chemical Society*

Date	Total number of articles	Number of articles containing mathematical equations	Percentage of articles containing mathematical equations
1900 (Jan.–Jun.)	63	1	1.6%
1910 (Jan.–Jun.)	88	10	11.4
1920 (Jan.–Jun.)	139	38	27.4
1930 (Jan.–Mar.)	206	34	16.5
1940 (Jan.–Mar.)	210	32	15.2
1949 (Jan.–Mar.)	379	40	10.5

seems to be no important trend but rather a sudden change from 1910 to 1920. Each year in this decade was then examined to determine whether the change was actually sudden or whether it was gradual throughout the decade. The latter is evidently the case as can be seen from Table IV.

The articles utilized in Table III were further studied to find the number in which no mathematics beyond algebra and trigonometry is involved and the number requiring a knowledge of calculus of higher mathematics. For the decade years from 1920 to 1949 the ratio of articles requiring algebra and trigonometry only to those requiring calculus or higher was consistently approximate to 5 to 3.

Any systematic application of mathematics to biology seems lacking until the beginning of the second quarter of this century and it is not until 1938 that we find an attempt to develop a more or less complete system of mathematical biology. This was done by Nicolas Rashevsky who in that year published the first edition of his *Mathematical Biophysics*.[1] The following year he started the *Bulletin of Mathematical Biophysics*. He has developed a mathematical theory for such topics as cell diffusion, cell respiration, cell division, cell growth and movement, nervous excitation and inhibition, visual pattern perception, and others.

TABLE IV. ANALYSIS OF *Journal of the American Chemical Society*

Date	Total number of articles	Number of articles containing mathematics other than in tables	Percentage of articles containing mathematics
1911 (Jan.–Jun.)	88	5	5.1%
1912 (Jan.–Jun.)	103	8	7.8
1913 (Jan.–Jun.)	105	17	16.2
1914 (Jan.–Mar.)	63	7	11.1
1915 (Jan.–Mar.)	72	15	20.8
1916 (Jan.–Mar.)	75	9	12.0
1917 (Jan.–Mar.)	61	12	19.7
1918 (Jan.–Mar.)	66	17	25.8
1919 (Jan.–Mar.)	55	9	16.4

In conclusion the author would say that although there does not seem to be any steady trend of increase in the use of mathematics in any one science, there are periods in which each science is lifted to a new mathematical level as it were. This occurred in physics (and related areas of physical chemistry) with respect to the use of the higher mathematical methods of quantum mechanics in the late 1920's. It occurred in chemistry with respect to mathematics in general during the decade between 1910 and 1920. It has had its beginnings in biology at about 1940. The author is sure that the significance of these changes for science teaching in general education is not limited to the college level, but she is equally sure that it has nothing to do with the development of skill in solving numerical science problems. The significance lies more in the attitude of respect toward mathematical science which the instructor passes on to his students and in the insight into the role which mathematical equations have played in facilitating scientific discoveries which could scarcely have been made without their use.

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TEACHING OF MAPS AND GLOBES FOR BETTER WORLD UNDERSTANDING

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Our nation needs an informed citizenry trained for intelligent participation in global affairs. It is essential that our citizens be able to read and to use effectively various types of maps and globes. An increasing amount and variety of information is being shown on maps. Unless these tools are understood, advocates of conflicting ideologies will be able to use them to distort truth and to present their concepts in a convincing manner.

There is, therefore, an urgent need for citizens to be trained in the use of maps and globes. Untruths depicted graphically take on an appearance of authenticity, and people unable to make intelligent use of graphic aids can easily become victims of misrepresentation. As Clyde Kohn expressed it, "Advertisers and propaganda agencies have found maps useful as a medium for reaching the American citizen, in part, because he is so illiterate in the field of map interpretation." Even when standard projections are used, people can be misled because they are not trained in the science of map reading and, therefore, fail to recognize the special merits and to understand the inherent limitations of a given projection.

This material is designed to emphasize a few fundamental truths basic to an effective use of maps and globes in the classroom and to aid the teacher in locating materials for use in the instructional program.

BASIC CONCEPTS

1. *The earth is round; the globe is a miniature replica which shows global relationships as they actually exist.*

The globe is the *standard* against which to check departures from the truth which of necessity characterize each of the projections.

2. *No map is perfect; all have distortions which must be recognized and understood.*

No map can truthfully represent the globe in all of its aspects. The larger the portion of a sphere transferred onto a plane, the greater is the distortion. Ranking high among the features desired on maps are: (1) the preservation of area, (2) a constant distance scale, (3) true shape, and (4) compass directions running in straight lines. No one map can possibly preserve all these desirable features. Every map is a compromise in that it achieves one or more of these elements at the sacrifice of others. Therefore, a map that is excellent

for one purpose may be unsatisfactory for another. The Mercator projection is valued especially for showing compass directions as straight lines, but it is undesirable for many other uses because of its great exaggeration of area and distance. There is no need to discard any projection. Rather, one should use many different projections for the particular merits of each. Consequently, pupils need to be taught how to make intelligent use of a great variety of projections including, among others, world distribution maps on Goode's interrupted homolographic projection; Azimuthal Equidistant maps centered on various given points as Washington, D. C., the North Pole, London, Moscow, etc., for showing great circle routes or other global relations; the Mercator for showing rhumb lines (compass directions as straight lines); Lambert conformal for preserving a practically constant distance scale; Orthographic projections for studying hemispheres; and Mollweide's homolographic projections for showing world distributions.

3. *North is toward the North Pole.*

From unwise use of cylindrical projections, such as the Mercator, many pupils get the idea that north is toward the top of the map as the meridians extend as straight lines to the top. In most other projections, the meridians north of the equator tend to converge on a single point, the North Pole, as they do on the globe. Certainly, intelligent use of a variety of maps, especially a polar projection for the northern Hemisphere, would aid in developing the understanding that north is along the meridians toward the North Pole rather than toward the top of the map.

4. *South is toward the South Pole.*

Just as north is the direction measured along the meridians toward the North Pole, south is the direction measured along the meridians toward the South Pole, irrespective of the position in relation to the "bottom of the map."

5. *East and west are directions measured along lines of parallels, irrespective of the type of projection.*

The effective use of a variety of maps will facilitate the development of desired concepts related to directions.

6. *Maps that present the desired features and information clearly and without too much detail are effective tools of learning.*

Not only must many different projections be used—each for its particular merits, but different specialized types of maps are needed to present a variety of information. Too much detail should not be

included on any one map or the information becomes difficult to find and to interpret.

7. ***Wall maps, maps in books, outline desk maps, outline blackboard maps, U.S.G.S. maps and other small-sized maps, physical-political globes, project outline globes, pictures, and other visual aids, all have a place in instruction.***

The teacher should use each type of aid for the purpose it serves best so that each may supplement the others.

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Thralls, Zoe A. "The Use of the Globe." *Social Education*, 11: 165–166, April 1947.

Discusses a scheme for using globes from Grade 1 through 12.

War Department. *Elementary Map and Aerial Photograph Reading*. Washington, D. C., Superintendent of Documents, U. S. Government Printing Office, 1944. 116 p. 20 cents.

Contains illustrations and content material of great value to teachers.

Watkins, Laura Louise. "Map and Globe Requirements for Teaching Geography in the Fifth and Sixth Grades." SCHOOL SCIENCE AND MATHEMATICS, 48: 570–571, October 1948.

Gives both general and specific requirements for maps and globes for the teaching of geography in the fifth and sixth grades.

Whipple, Gertrude and James, Preston E. "Instructing Pupils in Map Reading." *Social Education*, 10: 205–208, May 1947.

Outlines the objectives of the study of maps and globes and analyzes seven stages for use in teaching maps.

Whitaker, J. Russell. "Polar Maps Are Not Enough." *Geography in School and College*, p. 62–64. Nashville, Tennessee, George Peabody College Press, 1948.

A critical analysis of the present-day use of polar maps.

Whittemore, Katheryne Thomas. "Maps." *Geographic Approaches to Social Education*, Nineteenth Yearbook, National Council for the Social Studies, p. 117–129. Washington, D. C., The Council, 1948.

Deals with the place of maps in social education and their function in a unit of work and outlines an effective program for the use of maps.

Wilson, Myrtle Brandon. "Preparation for Map Reading in Primary Grades." *The Grade Teacher*, 68: 35, December 1950.

Suggests activities out of which map study may grow.

World Publishing Company, The. *The Matthews-Northrup New World Atlas*. New York, The World Publishing Company, 1948. 47 p. 50 cents (paper) $1.00 (board).

Contains stratosphere maps of the world and provides information in addition to the maps showing political-physical aspects, strategic materials, and transportation.

Younge, Ena. "How this Map Feature Came into Being." *Library Journal*, 75: 430, March 1950.

Discusses needed equipment for map rooms.

SUMMER CONFERENCE FOR CHEMISTRY TEACHERS

The New England Association of Chemistry Teachers is holding its Thirteenth Summer Conference at Rhode Island State College, Kingston, R. I., Aug. 20–25, 1951.

The varied program of about 15 speakers will include:

Symposium on teaching of chemistry with emphasis on science in general education

Workshop on pupil participation in chemical demonstrations as a classroom project.

More teachers from all over the country are attending these conferences and bringing their families. This year we shall enjoy the new buildings of R. I. State.

MODEL FOR INTRODUCING OVERLAPPING TRIANGLES

ETHEL L. GROVE
311 B Cedar Crest Apartments, Tuscaloosa, Alabama

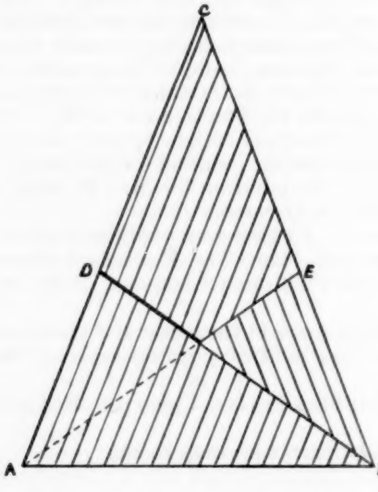
I. Construction

A. Materials

1. One cardboard rectangle approximately 15″×20″.
2. Two sheets of light-weight paper, of contrasting color, approximately 12″×15″.
3. Paste, scissors, pen, and India ink.

B. Steps in Construction

1. On the cardboard rectangle construct any convenient isosceles ΔABC with $AC = BC$.



2. On each sheet of the colored paper construct a triangle congruent to $\triangle ABC$ and outline with ink ($\triangle A'B'C'$ and $A''B''C''$). (If colored paper is not available shade these triangles with colored marking pencils.)
3. Cut out $\triangle A'B'C'$ leaving a one-half-inch flap along side $A'C'$.
4. Choose any point D on $A'C'$ and cut along line DB'. Outline edge DB' in each small triangle formed.
5. Fold flaps under and paste them to the model so that $C'D$ and DA' lie on AC and the other parts of the two small triangles coincide with $\triangle ABC$.
6. Cut out $\triangle A''B''C''$ leaving the flap along $B''C''$.

7. Choose point E on $B''C''$ so that $EB''=DA'$, cut along EA'' and outline edges EA''.
8. Fold flaps under and paste EC'' and EB'' along BC so that the two small triangles coincide with $\triangle ABC$.

II. Use

A. Teacher Demonstration

1. By using different combinations of the four attached trianglès this model can be used in the first presentation of overlapping figures to help pupils visualize the relationships in such figures and to understand the use of the sides and angles common to both triangles.
2. This one general model can be used to illustrate most exercises involving overlapping triangles when individual difficulties arise.

B. Pupil Investigation

1. This model should be left on the work table or bulletin board so that pupils may refer to it when they encounter difficulties in analyzing and setting up for themselves exercises involving overlapping figures.
2. Little is gained by preliminary pupil experimentation with this model before the topic of overlapping figures is introduced.

SOUTH DAKOTA PASSES POUND LAW

Passage of a "pound law" bill was enacted by the South Dakota Legislature and signed by the Governor on February 15th. The law becomes effective on July 1st.

The bill provides that animals needed for medical experimental purposes may be obtained under license issued by the State Department of Health from establishments maintained by municipalities for the impounding, care and disposal of animals seized by lawful authority.

Institutions that may apply for such license are schools and colleges of agriculture, veterinary medicine, medicine, pharmacy, dentistry or other educational or scientific institution properly concerned with the investigation of, or instruction concerning the structure of functions of living organisms, the cause, prevention control or cure of diseases or abnormal conditions of human beings or animals.

The State Department of Health is empowered to adopt rules and regulations necessary to insure the humane use of animals in such experimentation with the right to inspect or investigate institutions licenses or applying for license to secure experimental animals.

The South Dakota action brings to a total of three, states that have recently passed similar legislation. Thirty-one communities also have effected policies concerning the disposal of unclaimed impounded animals for medical use. Legislation is now pending in seven other states.

If arithmetic, mensuration and weighing be taken from any art that which remains will not be much.—PLATO.

NUMBER SCALE FOR ILLUSTRATING ALL FOUR FUNDAMENTAL PROCESSES WITH DIRECTED NUMBERS

ETHEL L. GROVE AND EWART L. GROVE
University of Alabama

AND

CHARLES E. SCOTT
Cleveland, Ohio

I. Construction
   A. Materials
      1. One strip of stiff cardboard approximately $5'' \times 20''$.
      2. Two dozen spring-type clothespins.
      3. Red and black ink and pen, or crayons.
   B. Steps in Construction
      1. On upper edge of cardboard strip, starting $\frac{1}{4}''$ from the left-hand end, mark off 26 three-quarter-inch spaces.
      2. Number these division points consecutively from -12 to $+14$. Set numbers back $\frac{1}{2}''$ from the edge and use red ink for negative numbers and black ink for positive values.
      3. Color one clothespin black or other convenient color.

II. Use
   A. This scale may be used to develop the rules for each of the fundamental processes by working out a sufficient number of examples on it that the pupils begin to recognize the pattern and suggest the rules for themselves.
   B. If the teacher has some other favorite method of introducing the rules for signs, this may be used for additional testing or illustration of the rules developed.
   C. This scale may be used to represent abstract number combinations, as described below, or to illustrate common situations, as temperature change, profit and loss, points won or lost in a game, etc.
   D. Manipulation of the scale for each process
      1. *Addition.* One addend indicates the beginning quantity and its position right or left of zero. The other addend shows the number of units to be combined with the beginning quantity and the direction of this operation. In all cases the starting point for the first addend is zero, and the values to the right of zero or changes in value from left to right are considered positive and values to the left of zero or changes in values from right to left are considered negative.

a. $+3$ added to $+5=+8$
Starting point, 0. Beginning quantity, $+5$.
$\therefore$ Place 5 pins to the right of 0.
Units to be added, 3. Direction, positive from $+5$.
$\therefore$ Place 3 pins to the right of $+5$.
Result, 8 pins to the right of 0. $\therefore$ The sum is $+8$.

b. -3 added to $-5=-8$
Starting point, 0. Beginning quantity, -5.
$\therefore$ Place 5 pins to the left of 0.
Units to be added, 3. Direction, negative from -5.
$\therefore$ Place 3 pins to the left of -5.
Result, 8 pins to the left of 0. $\therefore$ The sum is -8.

c. -3 added to $+5=+2$
Starting point, 0. Beginning quantity, $+5$.
$\therefore$ Place 5 pins to the right of 0.
Units to be added, 3. Direction, negative from $+5$.
$\therefore$ Remove 3 pins to the left from $+5$.
Result, 2 pins to the right of 0. $\therefore$ The sum is $+2$.

d. $+3$ added to $-5=-2$
Starting point, 0. Beginning quantity, -5.
$\therefore$ Place 5 pins to the left of 0.
Units to be added, 3. Direction, positive from -5.
$\therefore$ Remove 3 pins to the right from -5.
Result, 2 pins to the left of 0. The sum is -2.

e. $+5$ added to $-3=+2$
Starting point, 0. Beginning quantity, -3.
$\therefore$ Place 3 pins to the left of 0.
Units to be added, 5. Direction, positive from -3.
$\therefore$ Remove 3 pins to the right from -3, then add the remaining 2 units to the right of 0.
Result, 2 pins to the right of 0. $\therefore$ The sum is $+2$.

2. *Subtraction*. The difference between two algebraic quantities is usually defined to be the number of units that must be combined with the subtrahend to produce the minuend together with the sign indicating the direction of this operation. Hence, since the starting point for the difference is the subtrahend and differs in each case, mark that point with a black or other colored pin which will not be considered as a part of the result.

a. $+7$ minus $+2=+5$
Subtrahend or starting point, $+2$. $\therefore$ Place black pin on $+2$.
Required, number of units between $+2$ and $+7$.
$\therefore$ Place white pins on each space from $+2$ to $+7$.

Result, 5 white pins to the right of starting point.
$\therefore$ The difference is $+5$.

b. -7 minus $-2=-5$
Subtrahend or starting point, -2. Place black pin on -2.
Required, number of units between -2 and -7.
$\therefore$ Place white pins on each space from -2 to -7.
Result, 5 white pins to the left of the starting point.
$\therefore$ The difference is -5.

c. -7 minus $+2=-9$
Subtrahend or starting point, $+2$. $\therefore$ Place black pin on $+2$.
Required, number of units between $+2$ and -7.
$\therefore$ Place white pins on each space from $+2$ to -7.
Result, 9 white pins to the left of the starting point.
$\therefore$ The difference is -9.

d. $+7$ minus $-2=+9$
Subtrahend or starting point, -2. $\therefore$ Place black pin on -2.
Required, number of units between -2 and $+7$.
$\therefore$ Place white pins on each space from -2 to $+7$.
Result, 9 white pins to the right of the starting point.
$\therefore$ The difference is $+9$.

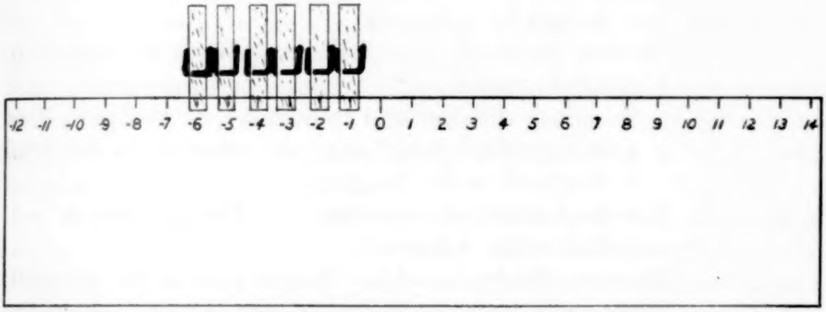
e. $+2$ minus $-7=+9$
Subtrahend or starting point, -7. $\therefore$ Place black pin on -7.
Required, number of units between -7 and $+2$.
$\therefore$ Place white pins on each space from -7 to $+2$.
Result, 9 white pins to the right of the starting point.
$\therefore$ The difference is $+9$.

3. *Multiplication.* Multiplication by a positive multiplier is usually considered to mean the repeated addition of the multiplicand the number of times indicated by the multiplier, starting from 0. Since $(-a)(b)=(b)(-a)$ multiplication by a negative multiplier may be considered as "negative additions" or repeated subtractions of the multiplicand the number of times indicated by the multiplier, starting from 0.

a. $+2$ multiplied by $+3=+6$
Starting point, 0.
Units to be added, 2. Direction, positive.
Number of additions, 3. $\therefore$ Place 2 pins (grouped slightly) to the right of 0, then 2 more, etc.
Result, 6 pins to the right of 0. $\therefore$ The product is $+6$.

b. -2 multiplied by $+3 = -6$
   Starting point, 0.
   Units to be added, 2. Direction, negative.
   Number of additions, 3. $\therefore$ Place 2 pins to the left of 0, then 2 more, etc.
   Result, 6 pins to the left of 0. The product is -6.

c. $+2$ multiplied by $-3 = -6$
   Starting point, 0.
   Units to be subtracted, 2. Direction, negative $[0-(+2) = -2]$
   Number of subtractions, 3 (negative multiplier).
   $\therefore$ Place 3 groups of 2 pins each to the left of 0.
   Result, 6 pins to the left of 0. $\therefore$ The product is -6.



NUMBER SCALE. (Illustrating -2 Multiplied by $+3 = -6$)

d. -2 multiplied by $-3 = +6$
   Starting point, 0.
   Units to be subtracted, 2. Direction, positive $[0-(-2) = +2]$
   Number of subtractions, 3. $\therefore$ Place 3 groups of 2 pins each to the right of 0.
   Result, 6 pins to the right of 0. $\therefore$ The product is $+6$.

4. *Division.* Division is usually defined as the reverse of multiplication, and perhaps in most cases developing the rules for division by considering the quotient as the missing factor in a multiplication problem is the best procedure. However, for those pupils who are sufficiently interested to ask how this can be illustrated on the scale, the following demonstration may be used. Since multiplication represents repeated additions, division may then be considered as a system for repeated subtractions of the divisor from the dividend. The quotient is the number of subtractions necessary to reduce the dividend to 0 or a remainder less

than the divisor. Similarly, a negative quotient represents the number of "negative subtractions" or additions needed to reduce the value of the dividend to 0 or a remainder.

a. $+6$ divided by $+2=+3$

Starting dividend, $+6$. $\therefore$ Place 6 pins to the right of 0.
Units to be subtracted, $+2$. $\therefore$ Remove 2 pins at a time until 0 is reached.
Result, 3 subtractions necessary. $\therefore$ The quotient is $+3$.

b. -6 divided by $-2=+3$.

Starting dividend, -6. $\therefore$ Place 6 pins to the left of 0.
Units to be subtracted, -2. $\therefore$ Remove 2 pins at a time until 0 is reached.
Result, 3 subtractions necessary. $\therefore$ The quotient is $+3$.

c. $+6$ divided by $-2=-3$

Starting dividend, $+6$. $\therefore$ Place 6 pins to the right of 0.
Units to be added, -2. (Addition necessary in this case to reduce the dividend toward 0.) $\therefore$ Add pins, 2 at a time, to the left of 0 until the value of the dividend is decreased to 0.
Result, 3 additions necessary. $\therefore$ The quotient is -3.

d. -6 divided by $+2=-3$

Starting dividend, -6. $\therefore$ Place 6 pins to the left of 0.
Units to be added, $+2$. $\therefore$ Add pins, 2 at a time, to the right of 0 until the value of the dividend is decreased to 0.
Result, 3 additions necessary. $\therefore$ The quotient is -3.

NEW SLIDEFILMS

At Home and School with Tom and Nancy is the title of a new slidefilm series produced in color photography by The JAM HANDY Organization. The series is based on one day's activities of twins in a primary grade.

Tom and Nancy are pictured in average home and school environments, with special emphasis placed on health, cleanliness, safety and recreation. The subject matter is organized to encourage desirable behavior attitudes toward accepting responsibilities, practicing courtesy, sharing with others, caring for belongings, developing independence, and being cooperative.

The six slidefilms are: "Tom and Nancy Start the Day," "The Safe Way to School," "A Busy Morning in School," "Lunch and Play at School," "The Birthday Party," and "Fun at Home."

All six full color slidefilms, packaged in a book-type box, are available for \$25.50. Individual slidefilms are priced at \$4.50. *At Home and School with Tom and Nancy* may be obtained from the JAM HANDY Organization, 2821 East Grand Boulevard, Detroit 11, Michigan, or through its distributors.

AN INVESTIGATION OF THE SUBJECT-MATTER COMPETENCE OF STUDENT TEACHERS IN SCIENCE

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Introduction

There appeared in recent issues of School Science and Mathematics two studies dealing with the subject-matter backgrounds of student teachers in science.[1,2] In essence, the data from these studies indicate the following:

1. Student teachers in science, in general, seem to be better prepared academically in biology than in physics, chemistry, or earth science. However, their superiority in biology is not statistically significant.

2. Student teachers in science, in general, are prepared significantly better in some one field than they are in the others. However, the field varies with the student. Hence, their training in the various fields of science is poorly balanced.

3. Student teachers in science, when compared with high-school pupils on tests in high-school science, score significantly lower on essay type questions than do high-school pupils. They obtain better scores on short-answer questions than do high-school pupils, but their superiority is not consistently significant.

Therefore, it may be concluded justifiably from these two studies that the training of these student teachers in science tends to be specialized. It would seem also that there is little evidence to indicate that they possess the knowledge of subject matter to teach science courses outside their special fields. Further, the emphasis in the training of student teachers in science tends to be placed more upon the learning of factual information than upon the ability to apply scientific principles.

However, neither of these studies provide evidence with respect to the following questions:

1. Is there any relationship between the number of semester hours in college science acquired by a student teacher in science and his knowledge in subject matter?

2. Is there a number of semester hours in college science that may be desirable in order that a student teacher in science know as much

[1] George Greisen Mallinson, "An Investigation of the Subject-Matter Backgrounds of Student Teachers in Science." School Science and Mathematics, XLIX (April, 1949), 265–272.

[2] George Greisen Mallinson, "A Comparison Between the Scores Obtained on a Science Achievement Test by Student Teachers in Science and by High-School Pupils." School Science and Mathematics, XLIX (December, 1949), 731–736.

science as his high-school pupils? (*This question is delimited to the scores obtained on tests in high-school science.*)

Hence it was the purpose of this study to seek evidence concerning these two questions.

Methods Employed

Four separate tests in each of the fields of Earth Science, Physics, Chemistry and Biology were constructed in the following way. The Regents Examinations of the University of the State of New York for the years 1944 and 1945 were selected as the source of the various test items. These examinations are prepared by the state, and are used to measure the achievement of high-school students after a year's study in the respective subject-matter areas. They were selected as the source of the test items since data were available concerning the average score received on each of the test items by a representative sampling of over 1,000 students taking them.

First, from Part I of the examinations on Earth Science was taken a random sampling of thirty short-answer questions, to each of which was assigned a value of one point. Each of these questions was written on a sheet of paper together with the average score received by the students who had answered that question. Next, were selected thirty short-answer questions from the examinations on Biology. These questions, however, were selected so that each of the questions on the examination on Earth Science was matched with a question on the examination on Biology with respect to the average score received by the students who had answered it. This same procedure was used in selecting thirty items for the examination on Physics, and for the examination on Chemistry.

From the thirty items on each of the four examinations, twenty-five were selected and so matched that the average scores on the corresponding items in the four tests varied by not more than .02 of a point. It could be assumed, therefore, using the average score obtained by the sampling of students taking these examinations, that the tests were of almost the same difficulty.

A similar procedure was used for selecting an essay type question from Part II or III from each of the Regents examinations. From Part III of the examination on Earth Science was selected a question, having a value of 10 points, requiring the application of a scientific principle for each of five parts. Then, from either Parts II or III of the examinations on Biology, Physics and Chemistry was selected a similar type of question, whose average score on the basis of the pupils' marks, did not vary more than .2 of a point from the average total score of the examination question of Earth Science. It

could, therefore, be assumed that these questions were of almost the same difficulty.

For the purposes of this study, a .02 point difference in difficulty was allowed between the short-answer items, and a .2 point difference in difficulty on the essay type questions, because a 3 per cent correction error is allowed by the state for determining the passing grade of 65 per cent on the examination when used by the high schools. A 3 per cent variation on a one point short-answer item would be .03 and on a 10 point item .3. However, prorated on the basis of the passing grade of 65 per cent, rather than on the perfect-score basis, the variation would be .02 for a one point item and .2 on a 10 point question.

The items were then made into a composite test of 100 items, 25 from each of the four areas, Earth Science, Biology, Physics and Chemistry, in that order for Part I. Part II consisted of one five-part question in Earth Science, followed by a corresponding question in each of the fields of Biology, Physics and Chemistry. It should be stated here that the items appearing on all of the tests were representative of the areas found in the respective syllabi prepared by the state.

Five state teachers colleges and one university school of education, all in the midwestern part of the United States, agreed to participate in this study, in accord with the plans set up for administering the composite test. During the months of April and May of 1948, the composite tests were administered to all the student teachers in science at the secondary level in these institutions, and were returned to the writer for scoring. The short-answer items were assigned a value of one point each and each essay question was assigned a value of twenty-five points, five points for each part. The total possible score was therefore 200 points. In order to reduce the possibility that a low score on the final section of Part I or II might be caused by failure to complete that section, those tests were discarded on which the last four items of Part I, or the last two sections of Part II, had not been answered. Seventy-nine usable tests were thus obtained. The results were then tabulated and analyzed.

The tests were then administered to high-school pupils in the same states as those in which the student teachers had been trained. The high schools selected were those having enrollments of below two hundred and fifty, since the newly-graduated teachers seemed likely to be employed first in such schools. Five schools agreed to participate in this study.

The tests were administered to all of the pupils in these high schools who were "majors in science." A "major in science" was considered to be a pupil who had taken a course in ninth-grade gen-

eral science and who also at the time of the experiment was taking either physics or chemistry. The system for grading and for scoring the examinations was the same as that used for grading and scoring the test papers of the student teachers.

After the tests had been received, the numbers of pupils were reduced by considering only those who had taken general science in the ninth grade and who had taken two of the "high-school sciences,"

TABLE 1. MEAN SCORES OF STUDENT TEACHERS CLASSIFIED ACCORDING TO SEMESTER HOURS OF CREDIT IN COLLEGE SCIENCE

Semester Hours	Average Scores											
	Earth Science			Biology			Physics			Chemistry		
	SA*	Es†	Comp‡	SA	Es	Comp	SA	Es	Comp	SA	Es	Comp
0 – .99	11.3	13.2	24.6	9.2	10.4	19.6	7.3	7.2	14.5	3.8	1.1	4.8
1.00– 1.99	—	—	—	—	—	—	—	—	—	12.0	0	12.0
2.00– 2.99	13.7	14.3	28.0	10.0	11.5	21.5	6.0	5.0	11.0	4.0	2.0	6.0
3.00– 3.99	10.1	6.5	16.6	9.3	7.5	16.8	7.9	5.4	13.3	10.0	1.0	11.0
4.00– 4.99	12.8	16.0	28.8	15.0	4.0	19.0	12.0	7.0	19.0	11.0	0	11.0
5.00– 5.99	—	—	—	11.1	6.7	17.7	15.4	17.2	32.6	13.0	23.0	36.0
6.00– 6.99	11.5	11.5	23.0	15.7	13.3	29.0	15.2	16.0	31.2	10.6	2.8	13.4
7.00– 7.99	14.0	5.0	19.0	—	—	—	—	—	—	—	—	—
8.00– 8.99	11.7	13.7	25.3	14.4	14.2	28.6	16.2	18.4	34.6	12.1	4.1	18.2
10.00–10.99	11.0	9.0	20.0	13.0	12.0	25.0	15.0	18.3	33.3	13.2	5.6	18.8
11.00–11.99	—	—	—	18.5	22.5	41.0	—	—	—	—	—	—
12.00–12.99	—	—	—	15.0	10.5	25.5	—	—	—	15.0	18.5	33.5
13.00–13.99	—	—	—	19.5	23.5	43.0	11.0	17.0	28.0	15.5	10.5	26.0
14.00–14.99	17.0	20.0	37.0	19.0	24.0	43.0	—	—	—	15.0	8.5	23.5
15.00–15.99	—	—	—	15.0	5.0	20.0	—	—	—	20.0	20.0	40.0
16.00–16.99	—	—	—	13.3	21.3	34.7	—	—	—	19.0	15.0	34.0
18.00–18.99	—	—	—	15.0	17.4	32.4	16.0	22.0	38.0	15.0	6.0	21.0
19.00–19.99	—	—	—	20.0	8.0	28.0	—	—	—	16.5	8.0	24.5
20.00–20.99	—	—	—	16.3	22.7	39.0	—	—	—	17.0	18.5	35.5
21.00–21.99	—	—	—	16.0	14.5	30.5	—	—	—	—	—	—
22.00–22.99	15.0	15.0	30.0	22.0	23.0	45.0	23.0	25.0	48.0	20.0	0	20.0
23.00–23.99	—	—	—	21.5	12.5	34.0	20.0	22.0	42.0	17.0	15.0	32.0
24.00–24.99	—	—	—	19.0	25.0	44.0	—	—	—	—	—	—
26.00–26.99	—	—	—	21.3	22.6	44.0	—	—	—	—	—	—
27.00–27.99	—	—	—	—	—	—	16.0	6.0	22.0	—	—	—
29.00–29.99	—	—	—	22.0	25.0	47.0	—	—	—	—	—	—
30.00–30.99	—	—	—	19.0	17.0	36.0	—	—	—	—	—	—
31.00–31.99	—	—	—	16.0	15.0	31.0	—	—	—	—	—	—
32.00–32.99	—	—	—	19.0	23.0	42.0	—	—	—	—	—	—
40.00–40.99	—	—	—	—	—	—	20.0	19.0	39.0	—	—	—
43.00–43.99	—	—	—	—	—	—	24.0	23.0	47.0	—	—	—
70.00–70.99	—	—	—	—	—	—	24.0	24.0	48.0	—	—	—

* SA means short answer.
† Es means essay type.
‡ Comp means composite.

namely, earth science, biology, physics and chemistry. Eighty-three usable tests were thus obtained.

The first step was to tabulate the number of semester hours in courses in science that the student teachers had acquired in college. The mean scores obtained by the students on the various science

tests were then computed for the respective number of semester hours they had acquired. Table 1 contains this information.

Next coefficients of correlation were computed between the number of semester hours of college science the students had acquired and their respective scores. Table 2 contains these computations.

TABLE 2.* COEFFICIENTS OF CORRELATION BETWEEN NUMBER OF SEMESTER HOURS OF COLLEGE SCIENCE AND SCORES ON SCIENCE TEST

Science Field	Coefficients of Correlation	Level of Probability	Per Cent Reduction of Error in Prediction
Earth Science			
SA	.139	$P>.05$	—
Es	−.067	$P>.05$	—
Comp	.15	$P>.05$	—
Biology			
SA	.75	$P<.01$	34
Es	.65	$P<.01$	24
Comp	.75	$P<.01$	34
Physics			
SA	.62	$P<.01$	22
Es	.45	$P<.01$	11
Comp	.54	$P<.01$	16
Chemistry			
SA	.84	$P<.01$	46
Es	.55	$P<.01$	16.5
Comp	.77	$P<.01$	36

* The procedures used for computing the data in Table 2 are cited in J. P. Guilford, *Fundamental Statistics in Psychology and Education*. New York: McGraw-Hill Book Company, Inc., 1950. Pp. xiii+633. Citation for coefficient of correlation, pp. 162–4; for level of probability, Table D; and for percentage reduction of error in prediction, p. 409.

The data in Table 2 indicate that except for the field of earth science, the coefficients of correlation between the number of semester hours of college science acquired by the student teachers, and the scores they obtained in the respective fields of science are significant. This is true for scores on the short-answer and essay-type questions, and also the composite scores.

The next step was to determine the number of semester hours of science that seemed to be sufficient in order to assure that student teachers were as successful on the science tests as the high-school pupils taking them. Thus the mean scores obtained by the high-school pupils, i.e., short-answer, essay type, and composite, were computed. Table 3 contains this information.

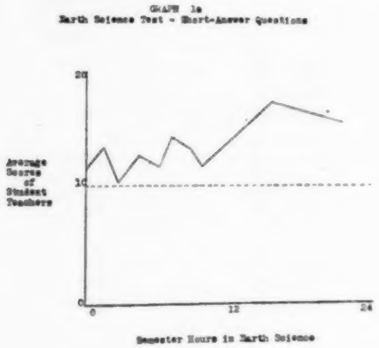
Graphs 1, 2, 3 and 4 compare the average scores made by the student teachers in science with those by the high-school pupils.

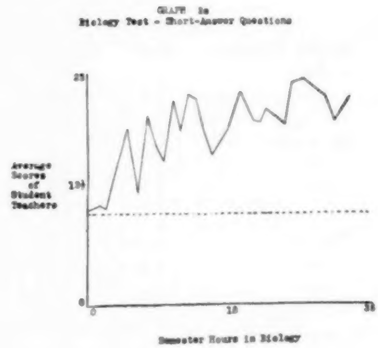
The horizontal broken lines in the graphs indicate the average scores made by the high-school pupils on the respective tests. The

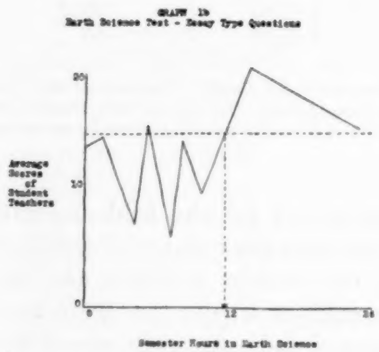
points at which the curves of the scores of the student teachers pass through these broken lines are referred to here as "critical points."

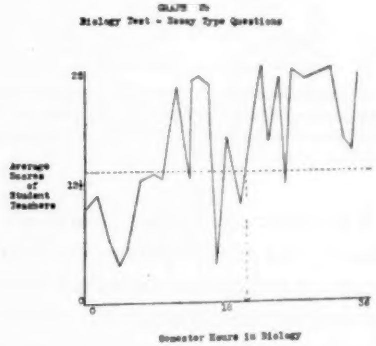
TABLE 3. MEAN SCORES OF HIGH-SCHOOL PUPILS ON SCIENCE TESTS

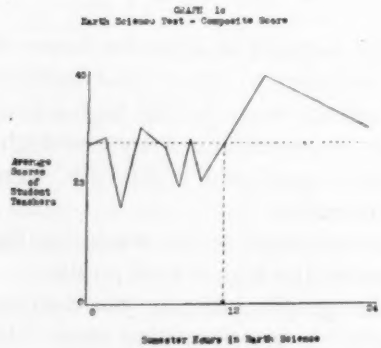
Field of Science	Short-Answer	Essay Type	Composite
Earth Science	10.00	14.79	24.79
Biology	9.07	14.67	23.74
Physics	10.34	14.71	25.05
Chemistry	11.68	10.58	22.26

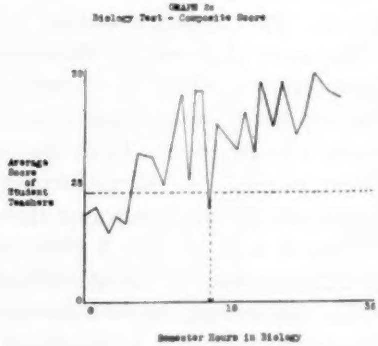




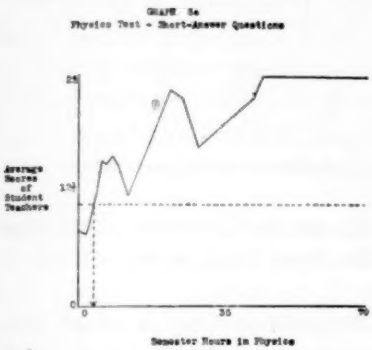


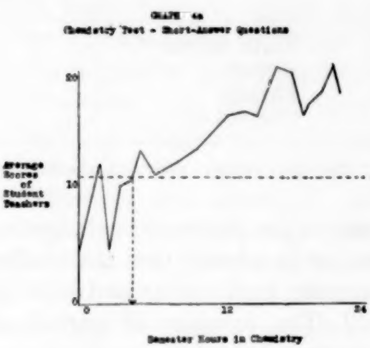


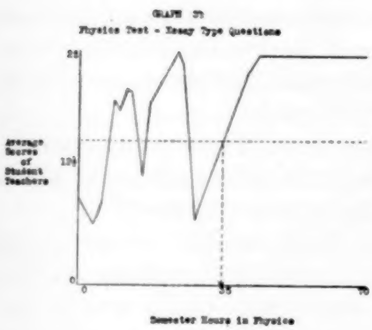


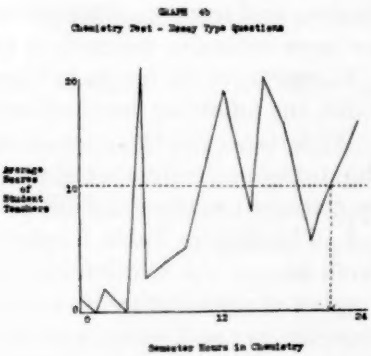


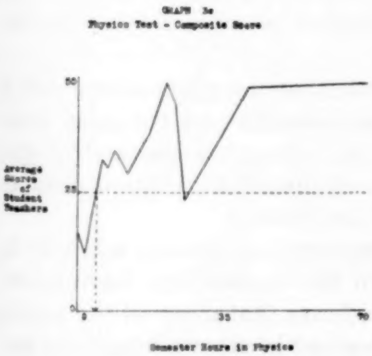
The critical points indicate *to a limited extent* the number of semester hours of science that seem sufficient in order to assure that student teachers are as successful on the science tests as the high-school pupils. Table 4 summarizes this information.

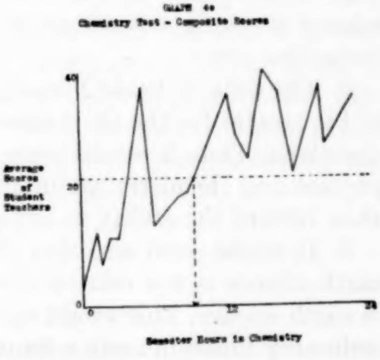












Conclusions and Recommendations

The conclusions and recommendations that follow are subject to these limitations.

1. The conclusions and recommendations may be applied directly

TABLE 4. SEMESTER HOURS OF COLLEGE SCIENCE AND "CRITICAL POINTS"*

Field of Science	Critical Points (in semester hours)		
	Short-Answer	Essay Type	Composite
Earth Science	—	11	11
Biology	—	20	16
Physics	5	34	6
Chemistry	5	21	9

* The critical points in Table 4 have not been determined mathematically, but are approximations.

only to the students participating in this study. However, there is no reason to assume that the students differ from those in other teacher-training institutions and high schools.

2. The number of participating students is only a small percentage of the number in the groups they represent. Hence the conclusions and recommendations may well be considered as implications for more extensive research in the area of teacher training in science.

However, in so far as the techniques used in this study may be valid, the following conclusions seem defensible:

With respect to Question #1 of the problem, "Is there any relationship between the number of semester hours in college science acquired by a student teacher and his knowledge in subject matter?"

1. The data in Table 2 indicate that for all fields of science except earth science the relationship between knowledge in science and the number of semester hours acquired is significant. This is true for the short-answer and essay type questions, and for the composite scores. This would seem to indicate that subject-matter competence in science is partly a function of the number of courses taken in the respective areas.

2. The data in Table 2 would indicate that the relationship stated in 1 is greater for the short-answer questions than for the essay type questions. Thus it would seem that the college courses in biology, physics and chemistry are oriented more toward acquisition of facts than toward the ability to apply and use them.

3. It would seem also that the competence of student teachers in earth science is not related directly to the courses they have taken in earth science. This would seem to indicate that many of the topics ordinarily found in earth science are learned in other science courses.

With respect to Question #2, "Is there a number of semester hours in college science that may be desirable in order that a student teacher in science know as much science as his high-school pupils? (*This question is delimited to the scores obtained on tests in high-school science.*)"

1. The data in Graphs 1, 2, 3, 4 and Table 4 would indicate that few hours of college science are needed in order for student teachers to acquire the facts ordinarily taught to high-school pupils. It would seem in most cases that the introductory course is sufficient.

2. However, the data in Graphs 1, 2, 3, 4 and Table 4 indicate that many semester hours of credit in college science seem necessary in order that student teachers answer essay questions as well as high-school pupils do. This would seem to indicate that the application of scientific information and the ability to apply principles of science are not primary objectives of science courses in college. It would seem that about twenty semester hours of biology and chemistry are necessary before student teachers can use and apply scientific facts as well as high-school pupils do. In physics about thirty-four hours are needed.

(It needs to be stated here that it is obvious that some students are likely to gain more than others from a course in science. Also twenty semester hours of science from one college should not be construed as equivalent to those from another.)

In view of the data obtained in this investigation the following recommendations seem defensible:

1. Assuming that subject-matter competence is necessary in order to teach science effectively, it would seem doubtful that such competence is developed by taking only one or two courses in the respective sciences. This refers to competence in applying and using scientific facts.

2. It would seem desirable that in courses in college science greater emphasis be placed upon the ability to apply and use the factual information that is learned.

3. It would seem desirable to investigate the possibility of further integration of the various courses in science at the college level. A great number of the students had apparently acquired knowledge in certain fields of science without taking courses in those fields. Hence, a sharp subject-matter demarcation is not necessarily indicated for effective learning.

Exposure suit, an Air Force development for airmen downed in water, will keep the wearer afloat and protect him from the weather. It is a one-piece coverall of water-proof material, sponge rubber closing around the neck, water sealed zipper in front, and rubber straps around the wrists.

Special cans, to provide pure drinking water in lifeboats and during emergencies when other water is not available, have an enamel protective coating on the outside but no inner lining as they are made of plated tempered steel. The can, only partly filled before sealed, will float on the sea.

MODELS USING DOCTOR'S APPLICATORS

Frank Hawthorne
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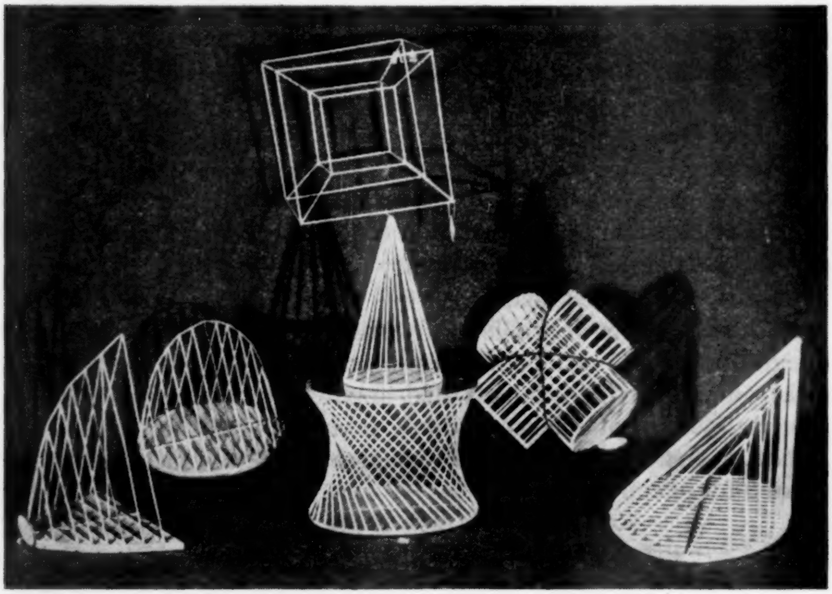
Wooden applicators, available at very small cost from any drug store, may be used to build very satisfactory and surprisingly durable models of various geometrical figures. These applicators are actually strong, uniform, straight-grained, White Birch dowels one sixteenth inch in diameter and six inches long. The easiest way to cut them to size is to use wirecutting pliers although single edged razor blades may also be used for this purpose. Students who have experience cutting Balsa with razor blades will be surprised to find that, unless considerable care is used in the cutting, the hard applicators will nick the blades. After the dowels are cut to size they should be fastened together with model airplane cement. These applicators are particularly useful in making three dimensional models illustrating solid geometry theorems.



The models pictured show only a few of the possibilities. Some of these models were designed to illustrate principles somewhat more advanced than those usually encountered in high school work but the technique used in their manufacture is readily applicable to simpler concepts. The top model is a three dimensional representation of the tesseract or hypercube. The central models are a simple cone and a hyperboloid of revolution of one sheet. The other four belong to the

class sometimes called "Solids of Known Parallel Cross Section" and are intended to aid the student of the calculus who is confronted with a description of one of these solids and a demand to find its volume.

The only materials in these models are applicators, paper beer coasters, plywood and cement. The total cost is very small. The beer coasters were glued together in pairs (with the advertising on the inside) to form the base of the cone and the ends of the two intersecting cylinders. A small piece of string was added to outline the volume common to the two cylinders.

INSTRUCTIONAL SOUNDFILMS FOR ELEMENTARY SCIENCE*

Joseph E. Dickman
207 S. Green St., Chicago 7, Ill.

The soundfilm is a powerful tool in the hands of the elementary science teacher. With it you can bring nature right into the classroom. Its ability to capture attention and to give vital experiences assure more learning in less time and with greater retention.

However, the problems arise in the selection and actual use of films. Finding the film you want when you want it is often difficult. To aid in selecting the film whose content matches the content of the unit being taught, the research department of Encyclopaedia Britannica Films has collaborated with the leading textbook publishers and published Film Selection Guides matching their films, unit by unit, with about 400 of the leading textbooks in the fields of Science, Health, Social Studies and Reading. These are available at print cost. Such Film-Textbook Correlations make film selection automatic, instead of hit-or-miss.

In the matter of proper use of films, once the right film is obtained, helpful Filmguides are available for instructional films. These help the teacher to know the content of the film, and contain vocabulary lists, discussion questions, activities for follow-up and reading references.

To make Filmguides more easily available to teachers at the point of use, EBFilms has recently made them available in handbook form at print cost. There are handbooks of about 50 guides each for Junior and Senior High School Science Films, Elementary Films, and for Junior and Senior High School Social Studies Films. Other subject areas will be added.

* Presented at the Elementary Science Section Meeting of the Central Association of Science and Mathematics Teachers Convention, Chicago, November 24, 1950.

An interesting new development recently written up in *Newsweek Magazine* is the publication, by D. C. Heath and Company, of film-readers for the primary grades. For the first time textbooks have been made to follow the content of motion pictures. For example, to go with the motion picture, GRAY SQUIRREL, there is a reader of the same subject to be used after the showing of the film. The reader has still pictures taken right from the motion picture, and, below the pictures, is the reading matter. With this film-textbook tieup, the pupil can be given the dynamic experience of viewing the film first, and then, reading the words which the film has made meaningful. In the places where this technique has been tried, experimentally, children have made phenomenal progress in reading. Science content can thus be introduced early in the reading program.

Year by year, the instructional use of motion pictures increases. This is to be expected in view of the power of the film as a communication tool.

MATH. TEACHERS LEARN INTERESTING WAYS TO TEACH SUBJECT

Local school children would have been delighted to see the puzzled looks on the faces of their mathematics teachers at the March 10 meeting of the Association of Mathematics Teachers in New England. The program consisted of twenty exhibits, each consisting of a game or puzzle based on a principle of mathematics. Typical exhibits were such brain teasers as Three-dimensional Tic-Tac-Toe, Geometric dissections, Mystic Pyramids, construction of Tanagrams, making and solving Magic Squares, Chinese Squares, making Moebius strips, and making geometric "faces."

The procedure for visiting the exhibits was governed by mathematical formulas that insured different partners at each table. The program was supervised by quiz-masters William R. Ransom, Professor Emeritus, Tufts College; Henry W. Syer, Assistant Professor, Boston University; and Mrs. Isabel Savides, teacher, Newton, Mass.

It is suspected that mathematics students in New England will soon be learning some of their mathematics through games and puzzles. The purpose of the meeting was to provide teachers with interesting teaching material that may be used to illustrate several of the principles of their subject.

ECHOES OF THE FIRST FIFTY YEARS

We are now on the march to the centennial anniversary of CASMT in November 2000.

Have you read about the great events of the half century period? A HALF CENTURY OF SCIENCE AND MATHEMATICS TEACHING, our anniversary contribution, projects the happenings in a most fascinating manner. There are two very important places where this attractive and highly informative book ought to be; viz., in your book collection and in the library of your school. Please enquire at these two places for us. Cost of the book is $3.00. Orders may be sent to

Mr. Ray C. Soliday,
P.O. Box 408, Oak Park, Illinois

The Promotion Committee

ARE WE USING OR ABUSING EDUCATIONAL FILMS IN OUR JUNIOR HIGH SCIENCE CLASSES?*

WILLIAM J. WALSH
Iowa State Teachers College, Cedar Falls, Iowa

As educators, we are genuinely interested in signs of progress in the child, methods of instruction, curriculum, and student experiences. Such signs are difficult to locate in many areas, while methods of evaluation sometimes end when the elusive sign of progress is almost within grasp. However, in glancing at the field of visual education, it is possible to observe discernible evidence of progress in use of projected materials in the field, in particular, the educational motion picture of the classroom. Progress is not limited, naturally, to projected materials, nor is it found only in the educational film. Nevertheless, the 16 mm. film of the classroom today certainly represents progress in a technique applied to learning activity.

As you know, the motion picture, as a mechanical technique is not new. Some investigators trace it to the early civilization of the Chinese and perhaps to eras preceding that. As an effective tool of learning, however, it has taken great strides from the smoky "Magic Lantern" of the past century or the "Great Train Robbery" of the entertainment field. There are many teachers today, in fact, who can recall the first appearance of the highly inflammable 35 mm. "movie" in the classroom accompanied by the precautionary bucket of sand or fire extinguisher. These teachers were potential firefighters as well as experimenters.

Viewed from present day standards, the educational classroom film, whether sound, silent, colored, animated or in slow motion, has evolved from an instrument of entertainment to a place of importance in the process of learning. This is especially true to the modern junior high science classroom.

As in the past, the field of science is one of the consistent leaders in the introduction and utilization of the modern educational film. With the wealth of materials and topics available, science lends itself readily to visual aids. Its areas are pointed and facilitate integration with available projection material. Although the 16 mm. educational film is the most used aid of the visual aid group for all content fields, many present rental and distributional agencies list science as the most consistent user of facilities and film titles. This is indeed a point of pride with many in our field, although it is often the tendency of

* Read before the Junior High School Group of the Central Association of Science and Mathematics Teachers November 25, 1950.

school systems to appoint the science teacher to the role of custodian, repairman, projectionist, and operator of film equipment unless a more "hefty" member of the staff can be drafted.

However, this indication of film usage does not necessarily correlate with progress in the learning activity. The purchaser or owner of an automobile is not assured a more successful trip to his destination than a pedestrian. Successful progress is possible, but depends, in large part, upon the auto and the driver. The use of a film, likewise, has the potential of being a more successful method of progress in learning only if the film is utilized and integrated successfully by the the teacher. Are we, as gross users and formulators of many present and future films of science, considering utilization in the light of the teachers as well as the film? In short, are we using or abusing the educational film in our junior high science classes?

Let's examine the picture. As junior high school science is basically a method of reaching experiences which are meaningful and valuable, it is only natural to turn to educational films. Research studies of the past and present point out many reasons why we as science teachers use visual materials, and in particular the film in our classrooms. A summary of such surveys points to the visual materials as supplying a base for: conceptual thinking, reduction of verbalism. motivating interest, more permanent learning, continuity of thought, as well as contributing to growth of vocabulary and depth and variety of meaning through experiences not easily secured in other materials.

There are other signs of progress and reasons for our use of educational films. Films are maturing in content, area, and professionalism. More content titles are made available daily. Methods of arrangement, lighting, sound, and scenarios are becoming more professional and less "pure entertainment."

Distribution of films has been improved, in part, through the efforts of private and governmental agencies. Although this is still a major problem, the increased number of titles and more direct methods of transportation have aided individual users. Industrial films are becoming more useful and not mere "advertisements-in-motion." Rental facilities have increased as have school purchases and district "pooling" of resources.

Designers of projection equipment are more attentive to class usage, weight, maintenance, and operation. The resulting ease of projection is reflected in more teacher-operators and fewer appearances of the school custodian as chief projectionist. For with teacher operation, the flexibility and versatility of the educational film comes more into its own.

Professional training institutions are becoming more attentive to the need of educational film utilization in the classroom and the

resulting emphasis in teacher education can be determined in novice teachers, in-service training workshops, and visual aid coordinators.

In the light of such trends, one is tempted to paint an optimistic picture regarding the present and future relationship of the science class and the educational film. Agreeably, evaluation by merit alone is difficult; however, let us examine some of the apparent weaknesses of the educational film as it is influenced before and within the classroom.

The spiral of inflation has curtailed operation and procurement of films and equipment. This can be evidenced in present budget allotments and in film and equipment production. Although the average visual aid cost per pupil, or cost per teacher unit, is at present inadequate, the future does not show signs of improvement. Departmental budget funds are diverted to other needy items when such funds are limited or curtailed.

As mentioned earlier, the distribution and timetable of film movements have many bottlenecks. Distribution troubles are paramount to the average junior high science teacher. Films are difficult to fit into a proposed teaching plan when ordered six to eight months in advance. And if so ordered, a delay of a day can often result in faulty utilization or faulty integration with the unit in progress. Such scheduling hindrances result in lack of preview time for the teacher, strain on preview and projection facilities, and negligence in proper utilization. It is often the major cause of the presentation of a film with the comment, "Today we have a film, children; here it is."

Under such stress, we often overlook the true character of an educational film. Compare it to a military vehicle, say a tank. The tank is designed for a particular purpose. It generally borrows heavily from non-military ideas in construction and fabrication. It can carry out its purpose only when manned and operated by trained personnel. Its presence and performance is only a part of a united plan with a common purpose. It is never designed as a substitute. It can undergo change and improvement, with a specific purpose intended. However, improperly used or inadequately operated, it loses a large part, if not all, of its effectiveness.

An educational film does not resemble a tank in shape, size, or weight, but can be compared in specific use. It is designed for a particular area, or is so arranged that particular areas can be stressed. It leans heavily upon entertainment film techniques in production, lighting, scenario and operation. It can be effective only if properly presented and utilized, otherwise its appearance represents, in the main, wasted effort. It is not a substitute for the teacher, but represents a device which can enhance or lend experiences to the learners in a particular manner as part of the total objective. Improperly

used, or used without discrimination, it represents an evil rather than an instrument of potential learning in the educational pattern.

So far, we have confined our study to the tangible mechanics of the science film. But a child in your class is the prime loss or gain of film utilization. We judge our success and progress in teaching, testing, and counseling by the reaction of the individual child or group. If a student is bored or misses the intent of our ordinary teaching endeavors, his reaction is generally evident, one way or the other. With a film presentation, however, few are the pupils who will protest a "movie," good or bad. We have no yardstick of evaluation in the reaction of the average student. Truthfully, we are in the dark when attempting surface evaluations. How is success or failure in a science film presentation influencing the student in the class?

We must assume that the child is the center of effort. All teaching philosophy, methods, equipment, and effort revolves around the boy in the first row, the girl in the third seat, or the "culprit" in the corner. An educational film can provide experiences or information that are otherwise impossible in the average classroom. Its versatility of animation, slow motion, time-lapse sequences, and microscopic enlargement make it valuable in many situations. A reconstruction of a moving electron within an atom is difficult to duplicate with other media while the time-lapse of plant roots reacting to stimuli cannot be otherwise portrayed with a semblance of gradual growth. We must recognize that the film is not a substitute for teaching. It is not a windfall to use when we're experiencing "one of those days." It does not take the place of the "real thing" nor can it replace the teacher. It does not react to individual thought and opinion nor provide, without assistance, the direction of learning. It is not intended for entertainment nor is it a solution for problems of discipline. Improperly or passively used, the educational film can dull the imagination of the pupil by completing the sensory highlight in thinking, rather than motivating it. It can provide a block to abstract thought in later education through encouragement of passive, non-critical thinking. It can confuse or create false impressions if explanations are faulty or inadequate. We, as teachers, are encouraging the formation of such pitfalls in the individual child by neglecting certain procedures in film utilization. How can we realize maximum benefits from a film in a science unit integration?

Before using a film we should be assured that the film will accomplish the purpose for which we intend it. If intended as a means of unit introduction it should deal in general with some topics, and specifically with others. We should be attentive to its potential interests, motivation, and prospects for individual research. As an instrument of science learning, we are concerned with its validity, accuracy,

conciseness, and timeliness. Few teachers of science will use a faulty thermometer, but many of the same teachers will use a silent film which has a Model "T" Ford as an example of modern transportation.

Of particular interest and importance in film selection is the grade level accommodation. As junior high science teachers, we are particularly concerned with the spread of grade level in reading ability, vocabulary, spelling, etc. In choosing new films for our classes we are primarily influenced as to grade placement by the recommendation or evaluation of the distributor, A catalogue distributed by such an agency was recently examined and roughly tabulated as to the science films pertinent to grade level. The majority of the film titles, both sound and silent, were of junior high through college, senior high through adult, junior high through adult, elementary through senior high, and elementary through college. Such a wide sweep of pointed interest in a film necessarily demands individual assistance or deletion by the teacher. Films devoted to specific areas of elementary, junior high, or senior high science are scarce. Many seventh grade science students are daily exposed to vocabulary, processes, and understandings which are designed for college or adult levels. Yet, rarely does the child protest. Listening and understanding are not synonymous with a child.

It is evident, therefore, that teacher selection of film topics is extremely important. But the integration of possible learning activities provided by the educational film can best be realized by diligent effort on the part of the instructor in establishing the learning device in the classroom. Such establishment depends, in large part, upon teacher preview. Many film titles are misleading and inappropriate for the original purpose for which they were ordered. Too often the films are used, nevertheless. If the film is acceptable, points of integration and film objectives are determined and noted for pre-film observation. Such pre-film activities are often made with the help of a class committee.

A common practice is to point to the desired unit and film objectives in a series of questions which are prepared for examination by the class before film presentation. Such questions or "points to look for" establish the responsibility of the group in viewing the film for specific as well as general points. Difficult terminology or expressions should be included for explanation in the pre-film showing. Unusual film techniques should be explained so that the appearnace of such is not confusing. Provisions or explanations for elimination of sound in certain sections or elimination of certain portions of the film can be plotted and explained, if necessary, before the showing. By attending to such details, the teacher and the pupils are better prepared for utilizing the points of emphasis and anticipating the visual experi-

ences which are presented by this media.

It is self-evident that the actual projection should be made under the conditions that are most ideal and available in the school, including attention to ventilation, seating, visual and auditory difficulties of the child. No small aid is the teacher or supervised student projectionist who adds to the smoothness of the presentation by proper attention to correct screening. Familiarity with such techniques comes only with practice and patience. Modern machine operation in itself is relatively simple.

The integral follow-up activities can clinch or weaken the presentation. Such activities include discussion of the pre-film questions, comprehension quiz, or integrated activities that arise out of points of the film. Additional reading, discussion, projects, or excursions can add to the effectiveness of the film in the science unit being studied. Thus, the full range of film motivation can be realized in adding to the total learning process of the unit.

We can see that viewed from a pattern of desired utility, the use of the educational film is an exacting process with full requirements upon the efforts of the producer, distributor, school, teacher, and child. We are working with a particular media of educational instruction. The misuse of such an aid poses difficulty for the individual child. We are overcoming by slow degree the early hindrances of the film itself, but are faced with the action of the individual teacher—action which is anchored in the desire for progress of the individual as well as broadening of experiences.

We as teachers need the understanding and educational fortitude to avoid the use of educational films as "entertainment movies." We must realize that they are not substitutes for the teacher and can be used unwisely in grade placement, content, and practicability.

Yes, as teachers, *we* must consider film utilization for *we* are primarily responsible for the use or abuse of educational films in the junior high classrooms.

All-purpose sprayer, for attachment to a garden hose, picks up concentrated solutions from a bucket and mixes them in a one-to-ten ratio with the water delivered. Water pressure does the work, and it can be used to apply insecticides, fungicides, weed-killing chemicals and soluble fertilizers.

Telephone equipment, for use in burning buildings by firemen wearing gas masks, permits two-way talk with others outside. It contains transmitter and earphones, which can be attached to most fire-fighting masks, and insulated cable for transmission. No batteries or other power sources are needed.

INSIDE THE ATOM

VIII. THE SECRET OF ATOMIC ENERGY

BARBARA R. BALZER
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When we talked about the fundamental particles, we said that the neutron was an especially useful sub-atomic particle because, having no electric charge, it is not repelled by the positively charged nuclei of the atoms at which it is shot. We learned that slow-moving neutrons were much more likely to get close to the nuclei of atoms than fast-moving neutrons, and that neutrons could be slowed down by being made to pass through water or paraffin.

Scientists carried on many experiments with slow-moving neutrons. Probably the most important thing upon which they experimented was the making of elements heavier than uranium. An Italian physicist, Enrico Fermi, working in Rome in the 1930's, thought that neutrons would be ideal for making a heavier element from uranium, which was then the heaviest element. He decided to try surrounding some uranium with slow-moving neutrons. He hoped that some of the neutrons might enter the uranium nucleus and stay there. The electrical charges inside the uranium nucleus might have to take new positions after the neutrons entered the nucleus, and a small particle like an electron or a positron might have to be thrown out of the nucleus to make the charges balanced, but then, Fermi hoped, he would have a new element, heavier than uranium.

The results of Fermi's experiments on uranium were not entirely clear. Electrons were thrown out of the nucleus as he had predicted, but so were certain radioactive substances. Fermi himself was not sure what had happened in the experiment. The same uranium-neutron experiments were done by others, but no one was sure exactly what the results were.

It is a little wonder, however, that in 1934 there was a delay in the progress of science. First Germany, then Austria and Italy, made it hard for scientists who questioned the new forms of government in these countries. Many of the scientists were forced to migrate to America, France, England, and Denmark.

Nevertheless, it was in Germany that the first clue to the understanding of what happened in the uranium-neutron experiments was discovered. Otto Hahn and F. Strassman, two German chemists, had made chemical tests on the products that were formed when slow neutrons hit uranium. It is interesting to know that they used radioactive tracers in testing the products of the experiment. They discovered that one of the products of the reaction was ***barium!***

This was strange to them, for uranium has 92 protons and 146 neutrons, while barium has only 56 protons and 82 neutrons. It is only a little more than half as heavy as uranium. Usually, when elements were transmuted, a small particle was given off and an element was formed which weighed only a little more or a little less than the element started out with. Scientists were puzzled: why was *barium* a product of the uranium reaction?

Two scientists who had already fled from Germany were working in Copenhagen, Denmark, and Stockholm, Sweden. They were O. R. Frisch and Lise Meitner. They had worked on uranium-neutron reactions before. Lise Meitner thought about the news from Germany, the news that barium was a part of the reaction. She had an exciting idea that perhaps when uranium absorbs a neutron it splits into two parts that are approximately equal. She told her friend Frisch about the idea, and the two Germans discussed the idea with Niels Bohr, the man who made the theory of the atom. Mr. Bohr was then directing a laboratory in Copenhagen, but he was just about to leave for America to discuss some problems with Dr. Einstein. Bohr brought the idea with him to America.

Lise Meitner's suggestion caused a commotion among American scientists in January, 1939. There were two reasons for the excitement, one of them very important. The first reason that the scientists were excited was that the barium which was formed when the uranium split is an element which is made with a larger loss of mass than many elements. When protons and neutrons get together to form the nuclei of atoms, they lose a little of their mass as a result of the binding of the particles in the nucleus. The binding of the particles together is called "packing" and the loss of mass per particle is called the "packing factor." Barium has a large packing factor; this means that if much mass is lost, much energy must be given off when the protons and neutrons form the nucleus. For mass can never be *lost*, but only changed into energy.

But another element besides barium had to result from the uranium-neutron reaction. The name of this element the scientists could find out easily if they assumed, according to Meitner's suggestion, that the neutron splits the uranium into two nearly equal parts. Uranium has 92 protons; barium has 56. Thus, the other part must have 36 protons. The element with 36 protons is krypton. Krypton has an even higher packing factor than barium; even more energy is released when it is made.

But scientists had known about the high packing factor elements for several years. Cockroft and Walton had discovered that when lithium splits into two helium atoms quite a bit of energy is released, but these energy-releasing experiments had been investigated and it

had been found that they couldn't be used to produce great amounts of energy because more energy was required to supply the proton or neutron bullets causing the reaction than could be gotten from the reaction. So the high packing factors of krypton and barium were not the main cause of the scientists' excitement. The greatest reason for their excitement can be discovered when we count up the neutrons of the elements that take part in the uranium-neutron reaction. Uranium has 146 neutrons; barium has 82, and krypton, 47. Barium and krypton together have 129 neutrons. That leaves 17 extra neutrons. Even if some of these neutrons combine with protons to form small molecules, or if they pick up electrons and change to protons, there is still the chance that a few neutrons may be free. It is this chance that caused all the excitement among the American scientists when Bohr told them Lise Meitner's idea.

For if there are free neutrons given off when uranium is split into barium and krypton, these free neutrons might enter other uranium atoms and split *them* into barium and krypton. Each time a uranium atom was split, more energy and more neutrons would be released. In this way the reaction would not only give off a lot of energy, but enough neutrons to keep itself going until all the uranium present had been changed into barium and krypton. This kind of reaction is called a chain reaction. It is the same kind of reaction that causes an explosion when an electric spark sets off a mixture of hydrogen and oxygen. The hydrogen and oxygen atoms combine to form water, but, in combining, they give off enough heat to make other hydrogen and oxygen atoms combine. These give off an even greater amount of heat in combining. Finally there is enough heat to cause all the remaining hydrogen and oxygen to combine at once in an explosion.

But the scientists were only imagining that all this might happen, *if* Lise Meitner's suggestion were true. The first job of the scientists was to find out if the uranium atoms really split into two nearly equal parts when entered by neutrons. The second job was to find out whether the splitting up of uranium really left free neutrons. Within a month, Frisch had proved that uranium fission was true. By March, 1939, three separate groups of scientists had investigated by three different methods the possibility that neutrons are given off. Joliot and his assistants in Paris, Fermi and his assistants in the United States, and a group of scientists at Columbia University found neutrons given off in uranium fission.

By the end of 1939, over one hundred research projects were studying the fission of uranium. Scientists discovered other elements that would split into almost equal parts when bombarded with fast-moving neutrons. They discovered other products of uranium fission. The most important discovery about uranium fission was that only

one of uranium's three isotopes underwent fission. Since the three isotopes of uranium, Uranium 238, Uranium 235, and Uranium 234, weigh so nearly the same amount, they were hard to separate. But scientists found ways to separate them, and discovered at last that only Uranium 235 underwent fission, and that Uranium 238 captured a neutron, but did not split. Besides this, the scientists found that the fission of Uranium 235 works much better with slow neutrons, but that fast neutrons are given off when Uranium 235 fissions. They discovered, too, that Uranium 238 captures fast-moving neutrons without fissioning. There is one hundred forty times as much Uranium 238 as there is Uranium 235. So there is a good chance that the fast neutrons that are given off by fission will be captured by Uranium 238 atoms before they can slow down enough to enter a Uranium 235 atom and possibly start a chain reaction—*if* the uranium isotopes are not separated. The only way to have a chain reaction was to separate Uranium 235 from Uranium 238, and this was a hard job!

But what about Uranium 238? It absorbs fast neutrons, but does not fission. What does it do? This was another road for the scientists to investigate. They found that Uranium 238 captured a neutron and, after rearranging the charges in its nucleus slightly, became a new element with 93 protons in its nucleus. This new element was named neptunium after the planet Neptune, which lies beyond the planet Uranus. The element neptunium was unstable, however, and formed a third element, plutonium, with 94 protons in its nucleus. Plutonium, the scientists discovered, was stable, and, more important, would absorb slow neutrons and would fission! Scientists speculated that plutonium *might* be a way of producing a chain reaction. It would be easier to get plutonium because its parent Uranium 238 is found in quantities over a hundred times as great as Uranium 235. And because plutonium is a different element from uranium, it would be easy to separate from the uranium.

When scientists figured out the tremendous possibilities for power if either of these chain reactions could be made to work, the results were amazing. The energy in a pound of Uranium 235 or plutonium, if it were released slowly, would be enough to furnish the electric current to keep twelve million 100 watt bulbs going for a ten hour day. If the energy were released all at once, a pound of Uranium 235 would explode with twenty million times the force of a pound of T.N.T. All of this energy might be a pipe-dream. Scientists might never figure out ways that would be practical for producing Uranium 235 or plutonium chain reactions. But the war that broke out in Europe in the late summer of 1939 made it necessary that scientists begin trying very hard to unlock the energy that was in the atom.

No longer was there free exchange of information among scientists all over the world. Instead of a co-operative venture among all the scientists of the world to release the great power of the atom for peacetime purposes, the war made a race of finding ways to keep chain reactions going in order to produce power from Uranium 235 or plutonium. The question of which side could unlock the secret first became suddenly the most important question of the decade.

In order to produce a chain reaction that would keep itself going, several conditions must be just right. The first condition is that the neutrons must be moving slowly enough for the Uranium 235 or the plutonium atoms to capture them. You will remember that scientists had previously used heavy water and paraffin to slow down neutrons. They thought that they might find other substances (called *moderators*) besides paraffin and heavy water. Some scientists thought that they could use pieces of light elements which would not capture neutrons, but would bounce them back.

The second condition is that the Uranium 235 must be very pure. Any impurities would be likely to absorb neutrons and keep them from producing other fissions. Scientists found that they could not have more than one part of impurities per one million parts of Uranium 235 or plutonium.

The third condition is that the neutrons do not escape. If the lump of Uranium 235 or plutonium is too small, there is a chance that the neutrons will get out into the air before they are absorbed by an atom. The lump large enough so that more neutrons stay in the lump than get out is called the *critical mass*.

Scientists thought of all these drawbacks before they asked the government for money to experiment on atomic power. They knew, too, that if they should get enough pure uranium or plutonium and enough pure moderator—for the moderator would have to be just as pure as the fission material—to make a lump greater than the critical mass, and *did* start a chain reaction, the chain reaction might get out of hand and blow up, or give off enough radioactivity to ruin a wide area so that people couldn't even live in it. They would need to plan their safety precautions very well. But they were racing against the possibility that Germany might discover the way to make a chain reaction go before the Allies did.

The United States government put up the money—a little at first, and then enough to amount to two billion dollars. They set university laboratories to work on research—at Columbia University, at the University of Chicago, and at Washington University in Saint Louis. The government built entire cities to produce plutonium. The Hanford Engineer Works in Washington had sixty thousand people working on the plutonium pile. There were scientists in little cities

scattered in different places in the United States working on problems connected with obtaining enough pure Uranium 235 and plutonium to make chunks of a critical mass.

On December 2, 1942, the first chain reaction pile was started under the stadium at the University of Chicago. Bricks of pure graphite as moderators were set up in a pile. Scattered through the pile were lumps of pure Uranium 235. Rods of cadmium metal were placed in various parts of the pile as a way of controlling the reaction. Cadmium absorbs neutrons but is not changed by them, thus the rods would slow down the reaction. They could be removed if the reaction was going too slowly. It was a good thing that the scientists had the cadmium rods, for the pile worked better than anyone had expected. The first atomic bomb was tested at Los Alamos, New Mexico, on July 16, 1945. The explosion, heat, and radiation that the world has since heard much about were there. The bomb worked.

Today we are concerned about keeping the secret of the atomic bomb. The only secrets of the atomic bomb are the way the uranium is purified, the way the bomb is put together, the size of the critical mass of Uranium 235 that will explode, and the ways in which better uranium and plutonium piles are made. There are none of these secrets which scientists and engineers in other countries can't unlock as well as American scientists did. They will need only the time and money for research.

The beginnings of the atomic bomb came in 1919 when alpha particles (helium nuclei) produced the first transmutation. They continued in 1932 when protons and neutrons were used to produce transmutations. They went further in 1934 when slow neutrons were used to produce transmutations. They continued in 1939 when Lise Meitner had her bright idea about fission.

The bomb depends upon all of these things. It depends upon transmutation by alpha particles, deuterons, and protons—for neutrons are always produced by bombarding first with one of these three particles. It depends upon the recognition of radioactive bodies coming from the neutron-uranium fission. Thus it depends upon all the work the Curies and Joliots and Lord Rutherford did on radiation. Indeed, the *real* secret of the atomic bomb is that there *is no* secret, but rather a long history of the co-operation of scientists of every country, all over the world.

A FLASHING NEON LIGHT

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An interesting demonstration for the physics class, which will also attract the attention of the non-science student, is a flashing neon light which may be placed in the physics demonstration case and continue to operate for $1\frac{1}{2}$ to 2 years.

The apparatus is arranged as in Fig. 1 where (L) is a Type NE-2 GE neon glow lamp, (C) is a .05 mfd capacitor, (R) is a resistor of about 60,000,000 ohms, and (B) consists of four 30 volt hearing aid batteries connected in series. This makes for a very compact piece of equipment.

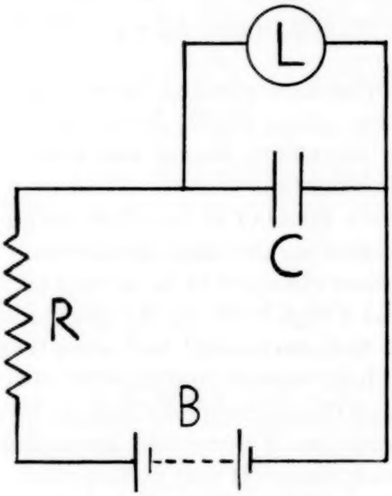

FIG. 1. Flashing neon light.

When operating, the battery (B) charges the capacitor (C) through the resistance (R) until the potential across the capacitor is about 90 volts. This is the voltage necessary to cause the neon lamp to glow. When this potential is reached, the capacitor partially discharges through the lamp. This process is repeated several times per minute.

At William Jewell College this apparatus was set up in a display case on March 28, 1949. At that time the bulb flashed 31 times per minute. Two years later, March 28, 1951, it was still flashing, but only 4 times per minute.

In constructing this equipment, it should be remembered that increasing the resistance decreases the frequency of the flashes, and

[1] Now at Vanderbilt University.

that an increase in (C) provides a brighter light at lower frequency. Also as the EMF of (B) is increased above 90 volts, the frequency of the flashes increases.

A TRIP TO THE MOON*

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If I were teaching astronomy and wanted to interweave sociodrama I would use a voice recorder.

Two years ago when I was teaching astronomy to an eighth grade science class I gave them this assignment: "Tomorrow we are going to take an imaginary trip to the moon. You are to do two things, one, arrange for your transportation and, two, make a list of all the things you need to take with you to stay for a period of one moon day and one moon night."

A tremendous enthusiasm resulted. Science books I had not been able to lure them into taking off the shelves before were read avidly. The school library, the village library and home reference materials furnished further information.

The next day every member of the class gave evidence of having enjoyed his preparation for this class discussion.

The number of facts obtained in so short a time was remarkable. Interest remained at a high level. As the discussion progressed it became very evident that each pupil had a particular interest in the trip. Several of the boys wanted to design the space ships, one of the girls wanted to design the stratospheric suits to be worn. One member wished to be a doctor, one a nurse, one an explorer, one a scientist; and so the plans took shape. It was at this point that I asked them how they would like to record their trip on wire so that it might be played back for other science classes. Needless to say this added further impetus to the work.

The trip was entirely pupil planned and directed. In a very short time it was ready for the first rehearsal. By now the trip had developed into three sections—the preparation, the trip itself, and the stay on the moon.

As I listened to the rehearsal I was aware not only of the science concepts but of the satisfactory way these children had worked together; of the way they had utilized the contribution of each member regardless of his ability, of all the learning that was exhibited in this twenty minute production that to any adult ear was far from a perfect production.

* Presented at the Elementary Science Section Meeting of the Central Association of Science and Mathematics Teachers Convention, Chicago, November 24, 1950.

This morning I have brought a disc recording of a small part of their trip.

Two of the contributions that meant the most to me as a classroom teacher are included. One is a girl's description of the space suit. This child found school work very difficult; and one is a short talk by a girl mechanic. This child is a little Mexican girl who had been in our speech correction department for three years and now for the first time found joy in reading aloud.

Now let's join them on their trip.

EGYPT TO HAVE OCEANOGRAPHY INSTITUTE PATTERNED AFTER ONE IN U. S.

The world's most-travelled sea, the Mediterranean, will soon be studied in the light of modern oceanography for the first time.

Dr. Abdel Fattah Mohamed, now a graduate student at the University of California's Scripps Institution of Oceanography, has been chosen to set up an oceanographic institution in his native Egypt.

It is designed to play much the same role in the eastern Mediterranean as the Scripps Institution does in the Pacific.

The new institution is to be the Alexandria Royal Institute of Oceanography, and Dr. Mohamed is to be its first director. It will be a branch of Farouk I University in Alexandria.

It is but part of a broad oceanographic program instituted by the Egyptian government to learn more about the contrasting seas which border Egypt on the north and east—the Mediterranean and Red seas. A second oceanographic institute will be established later at Suez.

Dr. Mohamed, who is a professor in the department of oceanography, Faculty of Science, Farouk I University, came to the United States as recipient of a Fulbright travel grant and a Smith-Mundt grant-in-aid. At the Scripps Institution he has been working with Prof. Norris Rakestraw and Dr. Edward Goldberg on his specialty, chemical oceanography.

PENICILLIN ALONE GIVES BEST RESULTS IN SYPHILIS

Doctors treating patients with syphilis can use penicillin alone and get satisfactory results. It is not necessary to give arsenic or bismuth or fever treatments with the penicillin.

This is the conclusion of eight syphilologists reporting jointly in the Journal of the American Medical Association.

It is eight years since Dr. John F. Mahoney of the U. S. Public Health Service first used penicillin to treat syphilis. Since then, the physicians reporting today state, "the accumulated experience of many syphilis clinics in treating thousands of patients of all types clearly indicates the superiority of treatment with penicillin alone in the vast majority of cases. It is only in an occasional case that supplemental treatment is necessary."

"Penicillin alone," they state, "far surpasses any previously used antisyphilitic remedy when appraised from the therapeutic, economic, technical, toxicity rate or prophylactic aspects. And most important, its high index of therapeutic accomplishments is enhanced by the simplicity of administration and its availability."

DOES THE ARITHMETIC IN ALGEBRA TEXTBOOKS PREPARE FOR TRIGONOMETRY?

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It is the purpose of this study to determine whether or not twenty-seven unselected college algebra textbooks provide exercises covering certain arithmetic fractions and radicals specifically prerequisite to the study of plane trigonometry and generally useful in college mathematics. The basic criterion used in determining the items deemed prerequisite to trigonometry was a report by Wolfe[1] of Brooklyn College in which he compiled a list of arithmetic items needed in the study of trigonometry there. This list was verified as having some general validity by the examination of three additional college textbooks in trigonometry. A further limitation on the items included was to restrict them to types found by the author or other investigators[2] to be a common cause of part of freshman deficiency with college mathematics. As a matter of fact more than 90 per cent of 278 freshmen at a large midwestern university missed such a simple problem as a decimal fraction divided by zero, which is one of the items included in this paper.

The following represent typical items together with their applications to plane trigonometry:

Item Number	*Example*	*Description*	*Application to Plane Trigonometry*
1.	$\frac{7}{64}+\frac{3}{16}$	The sum of two common fractions with different denominators	Given: $\tan A=\frac{7}{64}$; $\tan B=\frac{3}{16}$ Then $\tan(A+B)=\dfrac{\frac{7}{64}+\frac{3}{16}}{1-\frac{7}{64}\cdot\frac{3}{16}}$
2.	$\left(\frac{\sqrt{5}}{4}\right)^2$	Squaring a common fraction involving a radical	The sides of a right triangle are: 4, $\sqrt{11}$, $\sqrt{5}$ $\sin^2 A+\cos^2 A=\left(\frac{\sqrt{5}}{4}\right)^2+\left(\frac{\sqrt{11}}{4}\right)^2$
3.	$\sqrt{36+64}$	Given: two legs. Find hypotenuse.	Given: $\tan X=\frac{6}{8}$ What is the sine of X?

[1] Wolfe, Jack, "Mathematical Skills of College Freshmen in Topics Prerequisite to Trigonometry," *Mathematics Teacher*, 34: 164–70, April, 1941.

[2] Habel, E. A., "Deficiencies of College Freshmen in Arithmetic: Diagnosis and Remedy," SCHOOL SCIENCE AND MATHEMATICS, June, 1950.

4.	$\frac{2}{3}\cdot\frac{5}{9}-\frac{\sqrt{5}}{3}\cdot\frac{\sqrt{56}}{9}$	The difference of the products of two common fractions	Given: $\sin A=\frac{2}{3}$; $\cos B=\frac{5}{9}$ $\sin(A-B)=\frac{2}{3}\cdot\frac{5}{9}-\frac{\sqrt{5}}{3}\cdot\frac{\sqrt{56}}{9}$
5.	$\frac{\frac{1}{2}+\frac{3}{4}}{1-\frac{3}{8}}$	The sum divided by the difference of 2 common fractions	Given: $\tan X=\frac{1}{2}$; $\tan Y=\frac{3}{4}$. Then $\tan(X+Y)=\frac{\frac{1}{2}+\frac{3}{4}}{1-\frac{3}{8}}$
6.	$\frac{18+6\sqrt{2}}{6}$	Reducing a fractional, binomial quadratic surd	$9\sin^2 C-18\sin C+4=0$
7.	$\sqrt{\frac{1-\frac{1}{2}}{2}}$	Square root of a complex fraction	Given: $\cos 2A=\frac{1}{2}$; $\cos A=\sqrt{\frac{1-\frac{1}{2}}{2}}$
8.	$\sqrt{1-\left(\frac{\sqrt{5}}{4}\right)^2}$	Square root of difference between an integer and a common fraction squared	Given: $\sin X=\frac{\sqrt{5}}{4}$ Then the $\cos X=\sqrt{1-\left(\frac{\sqrt{5}}{4}\right)^2}$
9.	$\frac{3}{4}(0)$; $0-\frac{\sqrt{7}}{4}$	Zero multiplied by or added to a number	Given: $\sin A=\frac{3}{4}$; $\cos B=0$. Then $\sin(A-B)=\frac{3}{4}(0)-\frac{\sqrt{7}}{4}(1)$
10.	$\frac{0}{6}$	Zero divided by a number	$6\cos X=0$; Then $\cos X=\frac{0}{6}$
11.	$\frac{6}{0}$	A number divided by zero	Find the tangent of 90 degrees

Twenty-seven college algebra textbooks bearing a publisher's date of 1930 or later were found in the stacks of the Library of Congress on July 1, 1950. Examination of these textbooks revealed that only six of the items searched for appeared in any of the twenty-seven textbooks. The number of times any items were found similar to the ones listed here is displayed in Table 1.

It is true that the textbooks contained some exercises on arithmetical fractions, but they were definitely not pertinent to preparation for the study of plane trigonometry and not obviously pertinent to the study of any college mathematics. The whole point of this study is that exercises could just as well have been used that do have a relationship to the more advanced college subjects in mathematics. Although most textbooks did carry a stereotyped discussion of processes involving zero and the usual warning that division by zero is impossible, there was not a single exercise providing for practice with the fundamental processes involving zero. Several high school

textbooks examined failed in the same ways to provide coverage of these important arithmetic exercises.

TABLE 1

Item	Number of Textbooks	Total Number of Exercises
1	1	2
2	3	3
3	0	0
4	0	0
5	9	32
6	0	0
7	1	2
8	1	2
9	0	0
10	0	0
11	0	0

The table reads: Item 1 appeared in 1 textbook with 2 exercises, etc.

A consideration of the simple facts brought out in this article raises the following questions regarding courses of study and courses in mathematics—the answers to which may depend to a great extent upon the general objectives envisaged for mathematics as a study:

1. Should the simple arithmetical fractions and radicals, the simple algebraic fractions and equations needed to succeed with trigonometry be taught in the algebra course which usually precedes trigonometry?
2. Or should the teaching of the arithmetic and algebra needed in trigonometry be delayed until after the student enters the trigonometry class?
3. Should the minimum objective of any course in mathematics be a mastery of those concepts and skills necessary for success in the next higher course in mathematics?

The questions above are not proposed for the purpose of changing the topics included in the usual high school or college algebra course, but rather with the idea that a revision is needed in the types of exercises used in the textbooks to develop the traditional topics. Nor is it the purpose here to advocate preparation for college mathematics as the only or even the major objective of a high school course. However, there should be no quarrel with making preparation for the next higher course the minimum objective of a particular mathematics course. Too many students fail in college mathematics not because they are unable to understand the new concepts in the course but because of the combination of attempting the new work while they are straining for speed and skill with processes, many of which they met for the first time in elementary school.

It would certainly seem sensible and logical to synchronize courses in mathematics so that one shall lead smoothly into the next without jolt or hitch. There can be little justification for including in a text-

book content of no social significance when content could just as well be selected which would have an important relationship to the mathematics coming next semester or next year. Many exercises in mathematics textbooks have too much of the appearance of being what the author happened to think of at the time he was writing the book in order to give practice with a particular principle or rule; the exercises could just as well have been selected so as to be integrated with further courses in mathematics.

A METHOD FOR THE GRADING OF STUDENT REPORTS IN SEMIMICRO QUANTITATIVE ANALYSIS

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Probably the most perpelexing problem that the teacher who is teaching quantitative analysis for the first time has to solve is the assigning of grades to student reports. The beginning teacher has had no experience which would be of any help to him in estimating what a fair, and at the same time, sensible grade would be. This article was written to suggest to these teachers a method which will make the assigning of grades more objective. Also, there is suggested here a series of standards of performance by which the student reports can be compared to other classes in quantitative analysis.

After using the standards suggested here for a few years, the teacher may feel that he is justified by his experience to make some changes in the standards. But it is the belief of the author that the teacher will not want to use a different method from the one suggested here for changing his standards to a numerical grade.

The graph shown below was designed to obtain the percentage grade to be assigned to the student in semimicro quantitative analysis from the absolute error of his report. To illustrate the use of the chart: A report of a soda ash determination with an absolute error of .05% would be assigned a grade of 102%. (The grades over 100% are given to encourage superior work and also to give the student the chance to make up a very low grade which might have been assigned to an earlier report.)

The lower line has these co-ordinates: (110%, .00) and (30%, .5).

The upper line has these co-ordinates: (110%, .03) and (30%, .7).

By using the graph, the data in the last columns of the table given in this article were obtained.

As an example of the interpretation of the data in this table: In the

determination of the calcium volumetrically, 55 student reports were used. To standardize the .007 N $KMnO_4$ a 20 mg sample of $Na_2C_2O_4$ was weighed. Usually, four samples were needed to get the required precision of 3°/00. The abbreviation RMD is used to mean the Relative Mean Deviation, which is a measure of the precision. (The symbol, °/00, is used for parts in one thousand parts, or parts per thousand.)

Four samples of unknowns containing calcium were weighed out in amounts depending upon the percentage of calcium present. Since the samples ranged from 6% to 18% CaO, the students weighed out from 200 mg to 70 mg samples. Thus, a student with a 10% CaO sample was instructed to weigh out 150 mg. [This figure was arrived at by the following calculation: ($4/12 \times 130$ mg subtracted from 200 mg).] By thus varying the size of the starting sample, the student given the low-grade sample is not penalized as would be the case if all the samples were the same size.

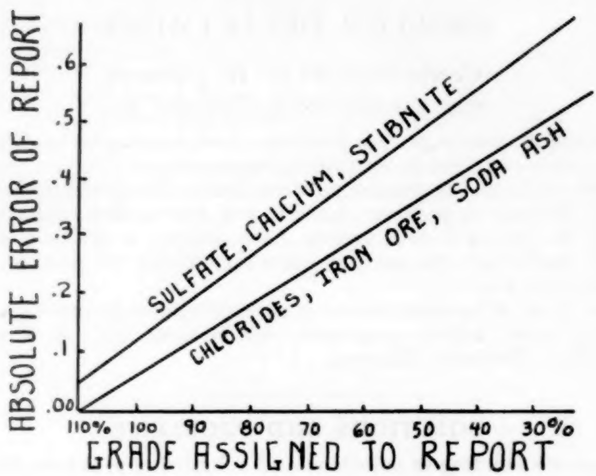
TABLE SHOWING THE GRADES OBTAINED ON THE VOLUMETRIC CALCIUM DETERMINATION

Determination	Number of Reports	Normity for a 50 ml. Buret	Weight of Material Taken for a Starting Sample		Range of Percentage Grades in These Percentile Groups			RMD for the Acceptance of Report	
			Standardization	Determination	Tenth	Fiftieth	Ninetieth	Standardization	Determination
Mohr Chlride	53	.021	50 mg. NaCl	15%—200 mg. 36%— 70 mg.	107%	95%	54%	2%	2%
Soda Ash	58	.021	50 mg. Na_2CO_3	30%—170 mg. 70%— 70 mg.	107%	90%	48%	2%	3%
Iron by Ceric	60	.02	50 mg. Fe Wire	20%—200 mg. 40%—100 mg.	108%	100%	83%	3%	2%
Stibnite by Iodine	55	.01	20 mg. As_2O_3	6%—200 mg. 18%— 70 mg.	106%	98%	71%	3%	5%
Calcium by $KMnO_4$	55	.007	20 mg. $Na_2C_2O_4$	6%—200 mg. 18%— 70 mg.	110%	101%	86%	3%	4%
Gravimetric Chloride	32			30%—100 mg. 70%— 50 mg.	106%	101%	73%		8%
Gravimetric Sulfate	32			20%—100 mg. 40%— 50 mg.	109%	94%	62%		12%

When the student had three determinations which check with a RMD of 4°/00 or less, he made his report to the instructor. If his grade was 70% or less, he was allowed to analyze a different sample of calcium at the end of the course after he had completed all his determinations.

From the graph the grades were assigned and the following distribution of grades resulted:

10% of the 55 reports received a grade of 110
50% of the 55 reports received a grade of 101 or better.
90% of the 55 reports received a grade of 86 or better.



JOBS FOR SCIENCE GRADUATES

Seventy-five per cent of the senior class which Case Institute of Technology will graduate in June already have received offers of employment, according to an announcement by Arthur E. Bach, Director of Placement at Case. Multiple offers of employment ranging from 2 to 16 jobs have been received by 40 per cent of the class which includes some 300 men.

Graduates of the Department of Engineering Administration have been most in demand with 80 per cent now offered jobs. Next largest demand is for mechanical engineers and for physicists.

The entire graduating class will be placed with employers by May 1, some 40 days before its graduation, Mr. Bach predicts.

The average salary of the positions being offered to the Case seniors is $300 a month plus. This average is a new high and compares with an average monthly salary of $269 received by seniors a year ago. The range of the salaries offered has been from $275 to $525 per month.

The nation-wide shortage of engineers is further reflected in the increase this year in the number of companies who are sending representatives to Case to interview seniors. Companies conducting job interviews at Case this year will number 244 as compared with 191 last year. Industry representatives also are hurrying this year to get their interviews with seniors early. The number of interviews in February this year was four times that of a year ago. Companies whose personnel representatives have already visited Case this year number 144 and representatives of 100 more companies are scheduled for interviews in the next few weeks.

Both personnel representatives and actual offers of employment are coming from firms having a much wider geographical distribution than in former years. Particularly noticeable this year is the increase of contacts with firms on the West Coast and in the Southwest.

For your vacation companion we recommend A HALF CENTURY OF SCIENCE AND MATHEMATICS TEACHING.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

Late Solutions

2233 and 2234. *Marie Moore, St. Louis, Missouri.*

2227, 2230, and 2234. *C. W. Trigg, Los Angeles City College.*

Note on Solution, 2208

Professor Julius Sumner Miller asked me to include the following note;

My problem #2208 is wrongly stated and wrongly solved! The ratio I gave and with which a number of solvers agreed holds for the nth and the $(n+1)$th second. For the intervals stated, namely the $(n-1)$th and the nth, the ratio is $2n-3/2n-1$, as analysis will show!

2239. *Proposed by Julius S. Miller, New Orleans, La.*

State in mathematical notation or symbols any ideas, concepts, theorems, equalities, etc. which impress you as being eminently beautiful and embracing. For example: the nine point circle, also $e^{\pi i}=-1$.

Items, so far sent, are:

$$\pi=\frac{10}{3}-\sum_{n=1}^{n=\infty}\frac{n!(n+1)!2n+2!}{(2n+3)!}$$

by Hugo Brandt, Chicago.

Ceva's theorem, Menelaus' theorem, Stewart's theorem, the remainder theorem and its corollary the factor theorem, Fermat's theorem $a^{p-1}\equiv 1 \pmod{p}$, to name a few. By Chas W. Trigg.

The Pascal Triangle is beautiful. By J. H. Means, Austin Texas.

$$\begin{array}{ccccccc} & & & 1 & & & \\ & & 1 & & 1 & & \\ & 1 & & 2 & & 1 & \\ 1 & & 3 & & 3 & & 1 \end{array}$$

The number 1729. Read the comment of G. H. Hardy to a friend about a visit to Srinivasa Ramanujan:

"I remember once going to see him when he was lying ill at Putney. I had ridden in taxi-cab No. 1729, and remarked that the number seemed to me a rather dull one, and that I hoped it was not an unfavorable omen. 'No,' he replied, 'it is a very interesting number; it is the smallest number expressible as a sum of two cubes in two different ways.'"

The above supplied by Julius Sumner Miller, New Orleans.

From an article, "The Number e" by J. L. Cooledge, *American Mathematical Monthly* appear two items:

$$i^{-i}=\sqrt{e^{\pi}}$$

$$\frac{e-1}{2}=\cfrac{1}{1+\cfrac{1}{6+\cfrac{1}{10+\cfrac{1}{14+\cfrac{1}{18+\cfrac{1}{\text{etc.}}}}}}}$$

From geometry there comes the astonishing relation that the circumcenter, centroid, nine point center and ortho center of a triangle are on a line, and also that two of the points, C and N, are separated harmonically by the other two.

2240. *Proposed by Cecil B. Read, Wichita, Kan.*

Show that in an evening of bridge the chance that any given player will have a hand void of some suit at least twice is better than one in three, assuming that 25 deals are made during the evening.

Solution by Charles McCracken, Jr., Cincinnati

Number of possible bridge hands = $C(52,13)$
Number of possible 3-suit hands = $4C(39,13)$
Number of possible 2-suit hands = $12C(26,13)$
Number of possible 1-suit hands = 4

$$\text{Probability of a void}=\frac{4C(19,13)+12C(26,13)+4}{C(52,13)}.$$

Applying the formula

$$C(n,r)=\frac{n!}{n!(n-r)!}$$

we find that the probability of a void occurring in a bridge hand is 0.0514 (to 4 decimal places).

We now apply the following theorem: if the probability of an event occurring is p and the probability that it does occur is q, the probability that it occurs exactly r times in n trials is $C(n,r)p^nq^{n-r}$. So our answer is represented by the sum

$$C(25,2)p^2q^{23}+C(25,3)p^3q^{22}+C(25,4)p^4q^{21}+\cdots+C(25,25)p^{25}q^0.$$

Putting in $p=0.0514$ and $q=0.9486$ and evaluating the first few terms we see that the probability of getting two hands with a void during the evening is approximately 0.358 which is greater than one in three.

2241. *Proposed by Julius S. Miller, New Orleans.*

Form the cubic equation whose roots are x_1, x_2, x_3 where

$$x_1=-\sqrt[3]{\frac{7}{2}+\frac{7}{18}\sqrt{-3}}-\sqrt[3]{\frac{7}{2}-\frac{7}{18}\sqrt{-3}},$$

the first term A, the second B

$$x_2=-\omega A-\omega^2 B$$
$$x_3=-\omega^2 A-\omega B.$$

Solution by James H. Means, Austin, Texas

Adding roots to get negative coefficient of x^2 term we get $(-A-B)(\omega^2+\omega+1)$ which is zero.

The sum of the products of the roots taken two at a time gives coefficient of x term which is $3AB(\omega^2+\omega)$ or $-3AB$.

Finally, the product of all the roots gives negative of coefficient constant term. $x_1x_2x_3=3AB(\omega^2+\omega)$.

The equation is $x^3-3ABx+3AB=0$.

Substituting for A and B we get

$$3AB=3\sqrt[3]{\frac{7}{2}+\frac{7}{18}\sqrt{-3}}\cdot\sqrt[3]{\frac{7}{2}-\frac{7}{18}\sqrt{-3}}=3\sqrt[3]{\frac{49}{4}+\frac{49}{108}}=7.$$

Therefore the cubic equation is

$$x^3-7x+7=0.$$

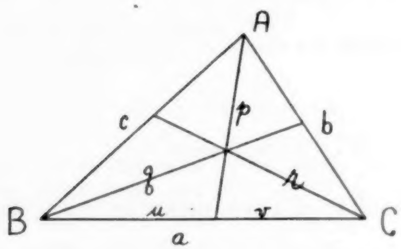
Others solutions were offered by: C. W. Trigg, Los Angeles City College; James Gray, Kirkwood, Mo.; Charles Tubbs, Racine, Wis.; Tadesse Terrefe, Mt. Pleasant, Iowa; Hugo Brandt, Chicago; B. B. Libby, San Francisco.

2242. *Proposed by D. L. Foster, Florida A and M College.*

If p, q, r be the bisectors of angles A, B, C, respectively, of a triangle ABC, prove that:

$$\frac{\cos A/2}{p}+\frac{\cos B/2}{q}+\frac{\cos C/2}{r}=\frac{1}{a}+\frac{1}{b}+\frac{1}{c}.$$

Solution by L. H. Lange, Valparaiso University, Ind.



By a theorem from plane geometry:

$$\frac{u}{v}=\frac{c}{b}$$

and, by the cosine law:

$$u^2=p^2+c^2-2pc\cos A/2.$$
$$v^2=p^2+b^2-2pb\cos A/2.$$

Combining, we have:

$$\left(\frac{u}{v}\right)^2=\left(\frac{c}{b}\right)^2=\frac{p^2+c^2-2pc\cos A/2}{p^2+b^2-2pb\cos A/2}.$$

This eliminates u and v, and, solving, we have:

$$\frac{\cos A/2}{p}=\frac{c+b}{2bc}=\frac{1}{2}\left(\frac{1}{b}+\frac{1}{c}\right).$$

Now, by cyclic permutation,

$$\cos A/2+\cos B/2+\cos C/2=\frac{1}{2}\left(\frac{1}{b}+\frac{1}{c}\right)+\frac{1}{2}\left(\frac{1}{c}+\frac{1}{a}\right)+\frac{1}{2}\left(\frac{1}{a}+\frac{1}{b}\right)=\frac{1}{a}+\frac{1}{b}+\frac{1}{c}\cdot$$

Other solutions were also offered by: V. C. Bailey, Evansville, Ind.; C. W. Trigg, Los Angeles City College; B. B. Libby, San Francisco; Walter Warne, Alton, Ill.; Mrs. Edith Warne, Alton, Ill.; Hubbell Loomis, New Haven, Conn.; James Gray, Kirkwood, Mo.; Hugo Brandt, Chicago.

2243. *Proposed by Dwight L. Foster, Florida A and M College.*

Derive the value of the integral (do not use methods given in calculus).

$$\int \sec\theta d\theta.$$

First solution, by V. C. Bailey, Evansville, Ind.

$$\int \sec\theta d\theta=\int\frac{d\theta}{\cos\theta}=\int\frac{\cos\theta d\theta}{\cos^2\theta}=\int\frac{\cos\theta d\theta}{1-\sin^2\theta}\cdot$$

Let $u=\sin\theta$. Then

$$\int\frac{du}{1-u^2}=1/2\ln\frac{1+u}{1-u}\cdot$$

$$\int \sec\theta d\theta=1/2\ln\frac{1+\sin\theta}{1-\sin\theta}=1/2\ln\frac{(1+\sin\theta)^2}{\cos^2\theta}$$

$$=1/2\ln(\sec^2\theta+2\sec^2\theta\sin\theta+\sec^2\theta\sin^2\theta).$$

$$\int \sec\theta d\theta=\ln(\sec\theta+\tan\theta).$$

Second solution, by the proposer

Let $\sin\theta=\lambda$, then $d\theta=d\lambda/\cos\theta=d\lambda/\sqrt{1-\lambda^2}$.

$$\int \sec\theta d\theta=\int\frac{1}{\sqrt{1-\lambda^2}}\cdot\frac{2\lambda}{\sqrt{1-\lambda^2}}$$

$$=\frac{1}{2}\int\left[\frac{1}{1+\lambda}+\frac{1}{1-\lambda}\right]d\lambda$$

$$=\frac{1}{2}\log_e\frac{1+\sin\theta}{1-\sin\theta}$$

$$=\log_e\frac{\cos\theta/2+\sin\theta/2}{\cos\theta/2-\sin\theta/2}$$

$$=\log_e\frac{1+\tan\theta/2}{1-\tan\theta/2}$$

$$=\log_e\tan\left(\frac{\pi}{4}+\frac{\theta}{2}\right)$$

$$=\frac{1}{2}\log_e\frac{\sec\theta+\tan\theta}{\sec\theta-\tan\theta}$$

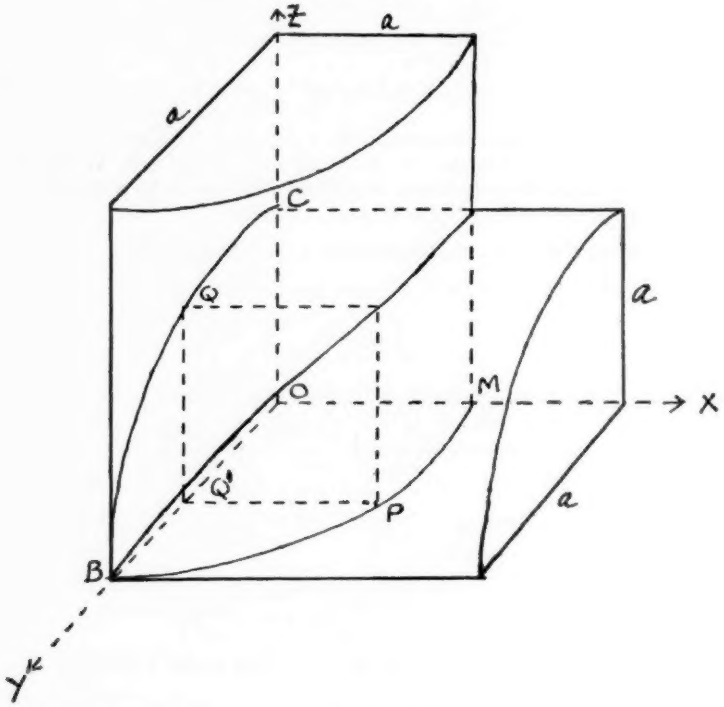
$$=\frac{1}{2}\log_e\frac{(\sec\theta+\tan\theta)^2}{\sec^2\theta-\tan^2\theta}$$

$$=\log_e(\sec\theta+\tan\theta).$$

2244. *Proposed by William R. Ware, Canby, Ore.*

In terms of base radius, find the volume common to three intersecting right circular cylinders, having the same radii whose axes are mutually perpendicular at the point of intersection.

Solution by Paul J. Malie, Hickory, Pa.



First, begin with the solution of the problem involving two intersecting right circular cylinders, having the same radii, a.

Let B-ZO-M represent one cylinder, axis OZ, radius a, and C-XO-B represent the second cylinder, axis OX, radius a. Then the volume of the section QM will be 1/8 volume common to the mutually perpendicular cylinders.

$$Q'P = QQ' = \sqrt{a^2 - y^2}.$$

Area section $QP = Q'P \cdot QQ' = a^2 - y^2$.

$$\frac{V}{8} = \int_0^a x^2 dy = \int_0^a (a^2 - y^2) dy = \frac{2a^3}{3}.$$

$$\therefore \quad V = \frac{16a^3}{3}.$$

Now, letting $x^2+y^2=R^2$, $x^2+z^2=R^2$, and $y^2+z^2=R^2$ be the equations of the three cylinders, the third cylinder cuts off from the volume of the two cylinders above in the first octant, a volume:

$$V = 2\int_{2^{-1/2}R}^{R} dx \cdot \int_{(R^2-x^2)^{1/2}}^{x} dy \cdot \int^{(R^2-2y)^{\frac{1}{2}}} dz = \frac{R^3}{3}(3 \cdot 2^{1/2} - 4).$$

Therefore, the volume common to the three cylinders is

$$\frac{16}{3}R^3 - \frac{8}{3}R^3(3\cdot 2^{1/2}-4) = 8R^3(2-2^{1/2}).$$

(Since "a" and "R" are one in the same, namely the radius of the cylinders, "a" may be replaced in the above.)

Other solutions were offered by: W. J. Cherry, Berwyn, Ill.; Hugo Brandt, Chicago; L. H. Lange, Valparaiso University, Ind.; Wm. Ware, Canby, Ore.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

2233. *Richard Lull, Arlington Heights, Ill.; Carl Burton, Chicago, Ill.; Ray Gallagher, Chicago, Ill.*

2234. *Shiao Wu, Tokyo American High School, Japan.*

2236. *Timothy Liu, Tokyo American High School, Japan; Miller Peck, Pittsburgh, Pa.; Bob Challener, Pittsburgh, Pa.*

PROBLEMS FOR SOLUTION

2257. *Proposed by Cecil B. Read, Wichita, Kan.*

If $A+B+C=180°$, prove that $\cot A+\cot B+\cot C=\cot A \cot B \cot C+\csc A \csc B \csc C$.

2258. *Proposed by C. W. Trigg, Los Angeles City College.*

Show that

$$\sum_{i=1}^{n} (-1)^{i+1} i^2 = (-1)^{n+1} \sum_{i=1}^{n} i.$$

2259. *Proposed by Dwight L. Forster, Florida A & M College.*

Eliminate θ between $m=\csc\theta-\sin\theta$ and $n=\sec\theta-\cos\theta$ and show that $m^{2/3}+n^{2/3}=(mn)^{-2/3}$.

2260. *Proposed by Hugo Brandt, Chicago, Ill.*

A crop of p objects is gathered by n people by sunset. In the night each person, in turn, unnoticed by the authors, discards one object (to make the pile divisible by n), takes from the pile $1/n$ of it and hides it. In the morning after one object is discarded, the pile is divided into n equal parts, each one's share being s. Find the smallest p and s in terms of n.

2261. *Proposed by Ralph E. Ekstrom, Fulton, Mo.*

If the arc AB of a circle is 20 and the chord is 16, find the radius.

2262. *Proposed by Doris Crane, Chatfield, Minn.*

If $\cos\theta/a=\sin\theta/b$, prove that $a/\sec 2\theta+b/\csc 2\theta=a$.

Doing an injury puts you below your enemy; revenging one makes you but even with him; forgiving it sets you above him.—BENJAMIN FRANKLIN.

BOOKS AND PAMPHLETS RECEIVED

BASIC HORTICULTURE, Revised Edition, by Victor R. Gardner, *Formerly Horticulturist and Director of the Agricultural Experiment Station, Michigan State College, East Lansing, Michigan.* Cloth. Pages x+465 15×23.5 cm. 1951. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $4.75.

ESSENTIALS OF COLLEGE ALGEBRA, by Joseph B. Rosenbach, *Professor of Mathematics and Head of the Department,* and Edwin A. Whitman, *Associate Professor of Mathematics, Carnegie Institute of Technology.* Cloth. Pages x+322+xxx. 13.5×20.5 cm. 1951. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.00.

THE YOUNG SCIENTIST, ACTIVITIES FOR JUNIOR HIGH SCHOOL STUDENTS, by Maitland P. Simmons, *B.Sc., M.A., Science Department, Irvington High School, Irvington, New Jersey.* Cloth. Pages viii+168. 13.5×21.5 cm. 1951. Exposition Press, 386 Fourth Avenue, New York 16, N. Y. Price $3.00.

A TEXTBOOK OF GEOLOGY, by Robert M. Garrels, *Northwestern University, Evanston, Illinois.* Cloth. Pages xvii+511. 15×23.5 cm. 1951. Harper and Brothers, 49 East 33d Street, New York 16, N. Y. Price $5.00.

ATOMS AT WORK, A PREVIEW OF SCIENCE, by George P. Bischof, *Brooklyn Technical High School, Brooklyn, New York.* Cloth. 130 pages. 13×20.5 cm. 1951. Harcourt, Brace and Company, 383 Madison Avenue, New York 17, N. Y. Price $2.25.

MODERN PHYSICS, by Charles E. Dull, *Late Head of Science Department, West Side High School, Newark, New Jersey;* H. Clark Metcalfe, *Science Department, Brentwood High School, Pittsburgh, Pennsylvania;* and William O. Brooks, *Science Department, Technical High School, Springfield, Massachusetts.* Cloth. Pages x+609+xxxi. 15×23.5 cm. 1951. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $3.48.

MODERN CHEMISTRY, Revised Edition, by Charles E. Dull, *Late Head of Science Department, West Side High School, Newark, New Jersey;* William O. Brooks, *Science Department, Technical High School, Springfield, Massachusetts;* and H. Clark Metcalfe, *Brentwood High School, Pittsburgh, Pennsylvania.* Cloth. Pages xi+564. 15×23.5 cm. 1950. Henry Holt and Company, 257 Fourth Avenue New York 10, N. Y. Price $3.40.

EVERYDAY ARITHMETIC, Junior Books I and II, by Harl R. Douglass, *Director, College of Education, University of Colorado;* Lucien B. Kinney, *Professor of Education, Stanford University;* and Donald W. Lentz, *Principal, Ridge Road School, Parma, Ohio.* Cloth. Book I, ix+488 pages, Book II, ix+502 pages. 1950. 13×20.5 cm. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $2.08.

TEXTBOOK OF ORGANIC CHEMISTRY, Third Edition, by E. Wertheim, *Professor of Organic Chemistry in the University of Arkansas.* Cloth. Pages xii+958. 15×23 cm. 1951. The Blakiston Company, Philadelphia 5, Pa.

PHYSICAL SCIENCES FOR HIGH SCHOOLS, by John C. Hogg, *Chairman, Science Department* and Harlan Page Amen, *Professor, The Phillips Exeter Academy, Exeter, New Hampshire;* Judson B. Cross, *Science Instructor, The Phillips Exeter Academy, Exeter, New Hampshire;* and Elbert P. Little, *Physicist, United States Air Force, Formerly Science Instructor, The Phillips Exeter Academy.* Cloth. Pages viii+531. 18.5×25 cm. 1951. D. Van Nostrand Company, 250 Fourth Avenue, New York 3, N. Y. Price $3.96.

HIGH SCHOOL PHYSICS, by Oswald H. Blackwood, *Professor of Physics and Education, University of Pittsburgh;* Wilmer B. Herron, *Head of the Physics De-*

partment, Butler High School, Butler, Pennsylvania; and William C. Kelly, *Assistant Professor of Physics, University of Pittsburgh.* Cloth. Pages viii+671. 15.5×23.5 cm. 1951. Ginn and Company, Statler Building, Boston 17, Mass. Price $3.76.

Modern Biology, by Truman J. Moon, *former Head of the Science Department in Middletown High School, New York;* Paul B. Mann, *former Head of the Department of Biology in Evander Childs High School, New York City;* and James H. Otto, *Head of the Science Department in George Washington High School, Indianapolis, Indiana.* Cloth. Pages x+698+lvi. 15×23.5 cm. 1951. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $3.96.

On the Origin of Species, by Charles Darwin. (A Reprint of the First Edition.) Cloth. Pages xx+426. 10×16.5 cm. 1951. The Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $3.75.

Jacobian Elliptic Function Tables, by L. M. Milne-Thomson, *Professor of Mathematics at the Royal Naval College in Greenwich, England.* Cloth. Pages xi+132. 12.5×19 cm. 1950. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.45.

The Elements of Mathematical Logic, by Paul C. Rosenbloom, *Associate Professor, Department of Mathematics, Syracuse University, New York.* Cloth. Pages iv+214. 12.5×19 cm. 1950. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $2.95.

The New Physics, by Sir C. V. Raman, *Professor of Physics, Calcutta University, Calcutta, India.* Cloth. 144 pages. 13×20.5 cm. 1951. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.75.

Logic and Language (A Collection of Philosophical Articles). Edited by A. G. N. Flew, *Lecturer in Moral Philosophy, King's College, Aberdeen.* Cloth. Pages vii+206. 13.5×21.5 cm. 1951. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $3.75.

Secondary Mathematics, by Howard F. Fehr, *Professor of Mathematics, Teachers College, Columbia University, New York.* Cloth. Pages xi+431. 14.5 ×22.5 cm. 1951. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $4.25.

The Fourier Integral and Certain of Its Applications, by Norbert Wiener, *Professor of Mathematics at the Massachusetts Institute of Technology.* Cloth. Pages xi+201. 13×20.5 cm. Dover Publications, Inc., 1780 Broadway, New York 19, N. Y. Price $3.95.

General Chemistry for Colleges, Fourth Edition, by B. Smith Hopkins, *Professor of Inorganic Chemistry, Emeritus,* and John C. Bailar, Jr., *Professor of Chemistry, University of Illinois.* Cloth. Pages x+694. 16×23.5 cm. 1951. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $5.50.

Professional Opportunities in Mathematics, prepared by a Committee of the Mathematical Association. Paper. 24 pages. 18×25.5 cm. January, 1951. Price 25 cents and 10 cents each for orders of ten or more.

Building America's Might, by the Director of Defense Mobilization, Charles E. Wilson. Paper. Pages iv+43. 20×26 cm. No. 1, April 1, 1951. Washington, D. C.

Statistics of Nonpublic Secondary Schools, 1947–1948, prepared by Rose Marie Smith, *Educational Statistician.* Paper. Pages iv+11. 15×23.5 cm. Superintendent of Documents, U. S. Printing Office, Washington 25, D. C. Price 10 cents.

INVENTORIES OF APPARATUS AND MATERIALS FOR TEACHING SCIENCE. Volume II, Universities. Paper. 146 pages. 15×24 cm. Publication No. 565. United Nations Educational, Scientific and Cultural Organization, 19 Avenue Kleber, Paris, France.

DIFFERENTIAL EQUATIONS, Third Edition Revised, by H. B. Phillips, Ph.D., LL.D., *Professor Emeritus, Massachusetts Institute of Technology.* Cloth. Pages viii+149. 13.5×21.5 cm. 1951. John Wiley and Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

RADIO AND TELEVISION RECEIVER CIRCUITRY AND OPERATION, by Alfred A. Ghirardi, *Author, Radio Physics Course, Modern Radio Servicing, Radio Troubleshooter's Handbook,* Assisted by J. Richard Johnson, *Co-Author, Practical Television Servicing.* Cloth. Pages xvi+669. 15×23 cm. 1951. Rinehart Books, Inc., 232 Madison Avenue, New York, N. Y. Price $6.00.

PLANE GEOMETRY, Revised Edition, by Frank M. Morgan, *Director of Clark School, Hanover, New Hampshire* and William E. Breckenridge, *Head of the Department of Mathematics at Stuyvesant High School in New York City.* Cloth. Pages viii+520+xi. 12.5×19.5 cm. 1951. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $2.32.

JOHANNES KEPLER: LIFE AND LETTERS, By Carola Baumgardt. Cloth, 209 pages. 15×23 cm. 1951. The Philosophical Library, Inc., 15 E. 40th Street, New York 16, N. Y. Price $3.75.

ZOOLOGY FILMS PREVIEWED

The following three zoology films, released by the International Film Bureau, Inc., of Chicago, were recently viewed by a group of college students and faculty members to determine their instructional values: THE NEWT (16 mm, sound, black and white), THE RABBIT (16 mm, sound, black and white), VEGETABLE INSECTS (16 mm, sound, color). All three films were rated high from the viewpoint of information and style of presentation. The only general criticism concerned the quality of the photographs, both black and white and color, but quality never prevented seeing clearly what was being depicted.

THE NEWT is a film showing the life history and habits of the Smooth Newt, which is generally distributed throughout the world and which has a typical life history of the group. The external differences between the male and the female are clearly shown, with excellent transition from artwork to actual photographs. The entire life history of the newt is shown in this combination artwork-photographic style.

THE RABBIT, likewise, is a life history film. Like THE NEWT, this film is British made. Consequently, some of the details of the life history do not compare with the life history and habits of our American rabbit, and the damaging effects of the rabbit are probably overemphasized because of the intensive truck patch agricultural system in the British Isles.

VEGETABLE INSECTS, produced by the Dominion Department of Agriculture of Canada, is a color film which emphasizes the economic aspects of entomology, and as the name implies, shows especially the garden insects. The film is particularly valuable because of the close-up pictures of various types of insect mouth parts. The lengthy instructions on insect control methods, which are good for the film's intended viewer, make the film of less value for general zoology classes but even more valuable for classes in general entomology.

All of these films are of the sort which you would like to see again and again in order to absorb and fully comprehend their content. The narration is not unnecessarily dramatic, as is often the case, but it is technical, professional, and still at the desirable student level.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

BOOK REVIEWS

STRUCTURAL CARBOHYDRATE CHEMISTRY, by E. G. V. Percival, *D.SC. Ph.D., F.R.I.C., Reader in Chemistry, University of Edinburgh,* Cloth. Pages viii+246. 13.5×21.5 cm. 1950. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.50.

This book summarizes the field of carbohydrate chemistry in a brief but fairly comprehensive manner. It is up to date in its treatment; much of the work described was done in the period of 1935 to 1948. However, the early work of Emil Fischer and his co-workers is fully outlined. The main emphasis is on properties, classification, structure, and configuration. Considerable attention is given to ring structure. Since emphasis is not placed on the mechanism of reactions, little or no attention is given to electronic concepts of structure.

The book is very easy to read and facts are clearly stated. Needed explanations are not given at the beginning in a single chapter but are made as required by the special topic under consideration. In the preface the author states the purpose of the book as follows: "This book is intended to be of service to students reading for an Honours degree in Chemistry, and to serve as a text-book in the later stages of preparation for ordinary and combined degrees and for examinations in biochemistry and pharmaceutical chemistry." This statement shows the possible use in an English university. On the American scene the book would be an excellent reference for senior and graduate students who have a major interest in organic chemistry. Certain chapters would make desirable reference reading for students taking their first year of Organic Chemistry; for example, Chapters I, II, and III give fundamental information needed by beginning students. A senior or graduate course in Carbohydrate Chemistry could be based on this book as a text. Industrial chemists dealing with problems of carbohydrate chemistry should have this book available.

GERALD OSBORN
Western Michigan College
Kalamazoo, Michigan

PHYSICAL CHEMISTRY, by Walter J. Moore, *Catholic University of America, Washington, D. C.* Cloth. Pages vii+592. 15 by 22.5 cm., 1950. Prentice-Hall Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.00.

This is a well written and well organized book. The approach is somewhat different from other texts of physical chemistry. The first six chapters give a rather thorough treatment of thermodynamics; thermodynamic laws and theory are correlated with such subjects as gases, solutions, changes of state and chemical equilibria. The seventh chapter deals with the kinetic theory and the next four chapters give a historical treatment of the structure of matter including nucleonics, quantum theory, and wave mechanics. Chemical statistics, crystalline structure and liquids are next treated. The final chapters cover such practical subjects as electro-chemistry, colloids and chemical kinetics.

It seems unfortunate that certain subjects of classical physical chemistry have been omitted. For example, various methods of molecular weight determination such as those of Victor Meyer and of Dumas are not included.

The treatment throughout is rather rigorous. Derivations of many basic equations are included. The author wisely feels that the method of organizing knowledge into a single mathematical formulation is important; he states in his preface "The derivations are important because the essence of the subject is not in answers we have today, but in the procedures that must be followed to obtain these and tomorrow's answers."

From what has previously been stated it is evident that a good solid background in mathematics, physics, and chemistry is needed by the student who would use this text. I feel that it is a little too difficult for the average college senior; a more elementary type of physical chemistry is usually taught at this level. It should be an excellent book for graduate students and research chemists.

GERALD OSBORN

ELEMENTARY ANALYTICAL CONICS, by J. H. Shackleton Bailey, *D.D.* Second Edition. Cloth. Pages ii+378. 13×19 cm. Oxford University Press, 1950. Price $1.75.

In the United States there has been a tendency in recent years to place less stress on the conic sections in our analytical geometry texts, and emphasize polynomial functions; likewise there are several books which combine analytics and calculus. This British text seems to cling to the classic tradition, with extensive treatment of the conics. The general topics treated in general parallel those to be found in our texts, but with considerable more detail, and with many points which are not found in the average text book.

It is very doubtful that this book would be found suitable as a text in most colleges, but it does provide a valuable source of reference material, well within the grasp of the superior student (or the beginning teacher). There are many suggestions for examination material, and some of the topics would provide material for a mathematics club program, for example, the chapter on oblique axes—a topic usually treated in very brief manner if mentioned at all. Interesting illustrations of the difference in terminology are provided at several points: the slope and gradient of a line as contrasted to the American terms inclination and slope; transference of axes rather than transformation of coordinates.

There are more than 750 exercises, with answers provided to the large majority. Some of these, taken from higher certificate examination papers, will present no little challenge to the student.

CECIL B. READ
University of Wichita

COLLEGE MATHEMATICS, by Charles E. Clark, *Associate Professor of Mathematics, Emory University*. Cloth. Pages v+331+46. 15.5×23.5 cm. Prentice-Hall Inc., New York, N. Y. 1950. Price $3.85.

In the preface the author points out that many students enter college with poor high school preparation in mathematics. With this in mind, his text is written both for students whose first college mathematics will be a terminal course, and for students who may go on to further study. Such dual purpose has not always been satisfactorily achieved in the past and it is doubtful if this book offers a completely satisfactory solution.

The material treated includes some work in trigonometry; differentiation and integration of polynomials; some work in algebra; work in statistics, including a treatment of correlation, of sampling, and of quality control; curve fitting; some elementary work in mathematics of finance. The treatment is not always traditional, for example, the words characteristic and mantissa are not used in connection with logarithms, nor is the standard form of writing the common logarithm of a number between zero and unity used. There is more treatment given to the subject of approximations than usually found in a first year text.

In some cases the author uses what might be termed a "non-standard" notation. Doubtless he feels there is value in this procedure, but one wonders whether or not this will be helpful to the student who may encounter "standard" notations in his reading or later courses. Examples are $dy(a, \Delta x)=a^2\Delta x$; Area $=\int_0^4(4-a^2)\Delta x$; $\cos -x=\cos x$; arc cos $-.35$.

In certain other places there would seem to be what must be classified as careless phrasing or else downright error: "We define $a^{-p}=1/a^p$ if p is a non-zero rational number." Does the author mean p, or a? "an angle with vertex at A consists of two line segments with a common end point A and the arc of a circle with one end point on each of the line segments and with center at A." If the definition is correct, he later treats certain configurations lacking the circular arc as if they were angles. ". . . if $-1\leqq x\leqq 0$ arc sin x is the measure of the largest negative rotation θ such that $\sin\theta=x$." Largest *numerically* or algebraically? There is no indication that the function involved is multiple-valued.

There are places where the treatment lacks clear statement, for example, in

Newton's method the student is told to get a number that is *near* the root. How near? No criterion is given, nor is there any warning that the method may fail even for a value "near the root." On page 195, discussing the correlation between number of years a student studies mathematics in high school and his grade on the final examination in first year college mathematics, it is stated that if $r=.95$, we can predict with great accuracy a student's performance in college mathematics from the number of years he studies mathematics in high school. The term "great accuracy" is indefinite and may be questioned by some, moreover there is the implicit assumption that performance in college mathematics is equivalent to grade on the final examination.

There is a reasonably adequate number of exercises, with answers to the odd numbered problems. Tables bound with the book include five place logarithms and five place natural trigonometric functions, natural functions for angles in radians, and a table of squares. In some places the printing gives a crowded appearance, especially in the lists of problems.

Whether or not the differences between this and other texts on the market are to the credit of this text will of course depend on the opinion of the individual instructor. To the reviewer, the disadvantages overbalance the good features.

CECIL B. READ

MATHEMATICS, QUEEN AND SERVANT OF SCIENCE, by E. T. Bell, *Professor of Mathematics, California Institute of Technology, Pasadena, California.* Cloth. Pages xx+437. 15×20.5 cm. 1951. McGraw-Hill Book Company, Inc., 330 West 42nd St., New York 18, N. Y. Price $5.00.

The author points out that this book is a thorough revision and a very considerable amplification of two of his previous popular accounts of mathematics: *The Queen of the Sciences* (1931) and *The Handmaiden of the Sciences* (1937). The style and high quality of writing is fully up to the standard of other outstanding books by this author.

This book should be in the library of every college and senior high school. It would be a splendid addition to any public library. It is not a text in higher mathematics, nor is it a reference book nor a handbook. Rather, it is an attempt to present some idea of mathematics as a whole, both pure and applied, showing not only how mathematics has developed, but how it is still developing. To illustrate the wealth of material discussed, one might mention just a few section headings—the list is by no means complete: the postulational method; rational, real, denumerable, non-denumerable, discrete, continuous, complex, analysis, function; rings; skew fields, linear algebras; transformations; matrices; graphs; algebra into geometry; space of many dimensions; one kind of topology; substitution groups; from Pythagoras to Descartes; from Descartes to Riemann; Fermat and Mersenne numbers; from Maxwell to radar; integration; periodicity; probability; counting the infinite. Even this partial list indicates the broad scope—the author has kept his objective well in view, not to write a textbook, but to indicate something of the spirit of modern mathematics and hope that some will be interested enough to wish greater knowledge.

The order of the chapters is not the traditional order in which the subject matter is studied, for example, discussion of mathematical logic and of number theory precede the discussion of calculus. This is relatively unimportant, for the chapters need not be read consecutively.

The treatment is not technical, yet in many places it will require reading and rereading in order to grasp all the implications. The reviewer found that with respect to material with which he was quite familiar the book seemed to present an exceptionally clear picture of the topic; with less familiar material the reading went more slowly. This may be kept in mind in the situation where someone not at all familiar with a particular subject is referred to this book, nevertheless this work is of exceptional value in suggesting to the young student (or for that matter, to some professional or business man no longer in school) what there is in

mathematics beyond that which he has already encountered. The teacher who wishes to have some insight into some of the present developments in mathematics cannot afford to ignore this means of adding to the store of his information.

The typography is excellent, the paper is good and at no place does one get a crowded appearance. Only one minor misprint was noted—it would appear (unless the point was missed by the reviewer) that the word *cone* on page 369 should read *one*.

CECIL B. READ

INTERMEDIATE COLLEGE ALGEBRA, by Edward M. Pease, *Ph.D., Rhode Island State College,* Pages vii+416+36, 14×20 cm., 1950. Published by Prentice-Hall, Inc., New York, N. Y. Price $2.85.

This is a text for college students who have had only one year of high school algebra. It contains the fundamentals of arithmetic and elementary algebra in addition to the material found in other standard texts on intermediate algebra for high school and college students. This review will consider the methods of presentation rather than the content of the text.

Each chapter begins with an introduction which lists the contents of the chapter and shows its relation to the work previously studied. At the ends of the chapters are found reviews and quizzes. These quizzes indicate to the student the degree of proficiency expected and serve as convenient reviews of the chapters. Careful consideration is given to the solution of verbal problems, including the ability to express the conditions of the problems in mathematical symbols. Most of the lists of problems are classified according to type, however there are a few miscellaneous lists.

There is a large number of worked exercises including both easy and difficult examples. Most of the solutions are carried out in detail showing reasons for the various steps. Frequently the students are warned against errors commonly made. There is a large number of well graded exercises with answers to about one half of them. The author lists twelve major steps in the development of the course. This shows the student the steps the author considers the most important, and should help the student organize the course for review.

Throughout the course the author stresses the nature of algebra and of the processes the students are learning. Examples of this are: a discussion of the nature of algebra in chapter I, a discussion of the nature of factoring on pages 137 to 142, and giving physical significance to equations on pages 70 to 75. These and other shorter discussions plus the logical development of the text should help the student understand the nature of algebra.

Much attention is given to the logical development of the course. Throughout the text the author states assumptions and gives reasons for such assumptions. A large number of formal proofs are given and the proofs are illustrated by numerical examples. The students *are* made conscious of the logic and of the need for it.

This text is well arranged and readable. It should be examined by instructors teaching students of the type for which it was written.

HILL WARREN
Lyons Township Junior College
La Grange, Illinois

DYNAMIC PLANE GEOMETRY, by David Skolnik, *Chairman, Department of Mathematics Central Commercial and Technical H. S., Newark, New Jersey,* with the Editorial Assistance of Miles C. Hartley, *Assistant Professor of Mathematics, Chicago Undergraduate Division, University of Illinois.* Cloth. Pages xii+289, 19×25 cm. 1950. D. Van Nostrand Company, Inc. Toronto, New York, London. Price $2.56.

On opening this text the eye notes that it differs from the usual "Plane Geometry." A part of this is the size and shape of the pages, the double columns, and the large number of figures. On looking for the "dynamics" one sees a con-

tinuous study of moving, changing, and flexible geometric figures. This is emphasized on page 2 by "Geometry—a Study of Motion." More than 2000 diagrams and exercises stress seeing and doing. They are effective and forceful-dynamic.

Perhaps, few students will care to do all of the more than 1200 exercises. They are, however, a rich source from which to select. Many are conveniently arranged for varying ability—basic, superior, and honor. This along with excellent summaries, reviews, and tests make this text very teachable. A minimum of supervision is necessary.

To be sure the book contains most of the ideas recommended for geometry in recent years. Part I is "The Meaning of Proof." Part II is "Patterns inThinking."

Anyone contemplating a change of plane geometry text will want to consider this book.

FOREST MONTGOMERY
Lyons Twp. H. S. and Junior College
La Grange, Illinois

EXPERIENCES IN SCIENCE, A WORKBOOK TO ACCOMPANY "SCIENCE FOR BETTER LIVING," by Paul E. Blackwood, *Specialist for Elementary Science, U. S. Office of Education.* Paper. Pages iv+156. 19.5×27 cm. 1950. Harcourt, Brace and Company, New York 17, N. Y. Price $1.20.

A work book or laboratory book used in connection with a science course can be of great value. It helps supply the repetition needed for thorough learning. A good work book stresses the more important or the basic concepts presented in the text and has great value in summarizing the text material for the student.

A work book should follow the general outline of the text. The questions presented should be based upon the text and the experiments discussed should be the more illustrative ones.

Paul E. Blackwood's *Experience in Science,* a workbook accompanying *Science For Better Living* fulfills these requirements to a fair degree. Although there is somewhat incomplete summarization of the individual chapters of the text, the treatment of the unit summarization is good. There might have been a more effective choice of the experiments presented.

BLANCHE BERLAND
Tilden Technical High School
Chicago, Ill.

THE ATOM AT WORK, By Jacob Sacks, *Brookhaven National Laboratory.* Cloth. Pages xii+327. 15×23 cm. The Ronald Press Company, New York. Price, $4.00.

This is a book that can be read with interest and profit by anyone who is interested in the implications for peacetime science of nuclear energy. Its purposes are "to describe in nontechnical language our present state of knowledge concerning the atom, isotopes, and radioactivity, and how this understanding has been reached," and "to show the constructive and hopeful side of the story of atomic energy." It begins with Democritus, and gives in simple terms enough elementary chemistry and physics to enable the reader to follow later developments. It closes with a chapter on the possibilities of developing useful power from nuclear reactions. Nearly a third of the book describes the use of isotopes, both radioactive and stable, in chemistry, biology, botany, medicine, and industry, bringing together in these chapters a great deal of information previously scattered in learned journals and similar technical publications.

The presentation is nontechnical throughout, but it is not mere popularizing. The statements are clear and accurate; sensationalism is avoided; yet fluency of style maintains interest and ease of comprehension. The book is particularly to be recommended to those who want to know something of the biological uses and effects of nuclear radiations.

JOSEPH D. ELDER
Harvard University Press
Cambridge, Mass.

APPLIED NUCLEAR PHYSICS, by Ernest C. Pollard, *Professor of Physics, Yale University*, and William L. Davidson, *Director of Physical Research, The B. F. Goodrich Company*. Cloth. Pages x+352. 15×23 cm. Second edition. John Wiley & Sons, Inc., New York. Price, $5.00.

The first edition of this book was published in 1942, the year in which the first nuclear reactor was operated at the University of Chicago. Since that time an immense amount of work on the nucleus of the atom has been done, and a great deal of it has been published. The authors have added to their earlier presentation in the light of new data, and have included new material as well.

The chapter titles give a fair indication of the material covered: randomness, reason, and atomic energy; properties of nuclear radiations; the detection of nuclear particles; methods of accelerating atomic particles; transmutation; radioactivity; technique in artificial radioactivity; artificial radioactivity in practice; stable isotopes and their application; nuclear fission; nuclear chain reactions; nuclear theory and cosmic rays. The last 50 pages comprise a number of valuable tables of data, including a complete table of atomic species, a new section on elementary pile theory, and a set of instructions for performing four instructive laboratory experiments, the materials and apparatus for which are not too difficult to obtain.

The emphasis of the book is descriptive, rather than mathematical. The authors "aim at presenting the essential facts in such a way as to be of service to the growing army of scientists and engineers who, though not necessarily versed in the language of physics, are using the products of nuclear physics in their respective spheres." They succeed admirably in achieving this aim. The writing is clear and accurate. Technical material is presented in such a fashion that it should be easily grasped by anyone who has had the introduction to the subject provided by a first course in chemistry and in physics. The principles of such newsworthy devices as the synchrotron and the bevatron are adequately presented with very little mathematics. The illustrations are aptly chosen and the figures are well drawn (though a draftsman's error in one of them makes the ion beam emerging from a cyclotron curve after it has passed the deflecting electrode.)

This book is full of information, and makes stimulating reading for anyone who is interested in the newest field of physics.

JOSEPH D. ELDER

THEORY OF MENTAL TESTS, by Harold Gulliksen, *Professor of Psychology, Princeton, and Research Adviser, Educational Testing Service, Princeton, New Jersey*. Cloth. Pages xix+486. 15×23 cm. 1950. John Wiley and Sons, Inc., New York, New York. Price $6.00.

The author explains the theory underlying the development of mental tests of all types. In so doing, he reviews the whole field of test theory from this one source.

Many of the basic statistical formulas now in use in test construction and in interpretation of test results are fully described. The author stresses the reasoning which led to these basic formulas and in addition gives a clear-cut derivation of each formula.

Students of statistics and measurement will find the book an excellent addition to their library for the author's treatment of many concepts is the best available. He has pulled together in one book, the assumptions and derivations on which many statistical formulas are based.

The concepts of validity and reliability and the factors which influence these concepts are given a most modern treatment.

The chapter on "Methods of Standardizing and Equating Test Scores" should prove to be extremely useful to test constructors.

All in all, this is one of the best books to appear in the field of measurement and evaluation, and students of education and psychology will find it extremely use-

ful both as a text and reference. The book should help to consolidate the recent gains in test construction and should do much to clarify the thinking of both of test users and test producers.

KENNETH E. ANDERSON
University of Kansas

MICROBIOLOGY: GENERAL AND APPLIED, by William Bowen Sarles, William Carroll Frazier, Joe Bransford Wilson, and Stanley Glenn Knight, of the *Department of Agricultural Bacteriology, University of Wisconsin.* Cloth. Pages xi plus 493. 15×23.5 cm. First Edition. 1951. Harper and Brothers, New York, N. Y. Price $4.50.

Separate courses in college bacteriology are becoming increasingly common across the country, but the beginning texts are few. Here's a text just published, designed especially to satisfy the beginning course need, yet it's not the result of an overnight compilation. The authors—all four professors of bacteriology—began preparation of the text ten years ago, and used it in mimeographed form in their courses at the University of Wisconsin. Through the years, the text has been revised and rewritten to fit the needs of all types of students and to strengthen its text in meaning and clarity. During the same period ten other colleges and universities used its mimeographed form.

The first third of the book concerns the fundamentals of microbiology. The remainder of the book is devoted to the microbiology of industrial, sewage, water, air, foods, milk, and milk products, and to the infection diseases of man, animals, and plants. The slant of the book is toward the general student rather than the professional student. The principles are applied across fields as much as possible and supported by numerous illustrations. Each chapter is concluded with a list of readings for further work.

Undoubtedly this book appears now in the first of many editions as more and more schools learn of it and adopt it for use in their courses.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

THE PRINCIPLES OF HEREDITY, by Laurence H. Snyder, *Dean of the Graduate College, The University of Oklahoma.* Cloth. Pages x plus 515. 14.5×15 cm. Fourth Edition. 1951. D. C. Heath and Company, Boston. Price $4.75.

A review of a textbook already in its fourth edition and adopted by more than two hundred and fifty colleges seems hardly necessary, for as in this case, the text is already well enough known to those who might use it. However, the announcement of a new edition is always valuable, and the revisions can be called to attention. This new edition of *The Principles of Heredity* contains all the significant developments made in the field during the past five years. Chapters XVIII and XIX incorporate the latest information known about the genetics of horses, cattle, poultry, and rabbits; and the discussion of blood groups includes the new HR antigens. The chapter on gene mutations incorporates the new material on chemical mutagens and on the genetic effects of radiation. A chapter formerly called "How Genes Act" has been rewritten and is now called "Biochemical Genetics" so that it includes the latest results of research on the control of enzymes by genes and on sex determination. The chapters on eugenics, too, contain much new material. Throughout the entire book revisions have been made to make use of developments of the past five years and to assure the continued popularity and value of the text.

GEORGE S. FICHTER

THE SCIENCE OF HEALTH, by Florence L. Meredith, M. D., *Fellow of the American Medical, American Public Health, and American Psychiatric Associations.* Cloth. Pages xiii plus 452. 15 plus 23 cm. Second Edition. 1951. The Blakiston Company, Philadelphia and Toronto. Price $3.75.

This is a text designed for use in elementary or beginning hygiene courses in colleges. Part 1 describes the national health situation and the structure of the human body. Part 2, which consumes the major portion of the book, is called Daily Maintenance of Health. Its chapters are on: circulation; muscles; supplying food, water, and oxygen; fatigue, rest, sleep, and recreation; cleanliness; infections; and injuries. Part 3 discusses the major health problems—both the communicable and noncommunicable diseases—in the United States. Part 4 is devoted to the various aspects of mental health, and Part 5 points out the relation of the individual to future generation through sex and heredity. There is a thorough bibliography at the end of the book. The text is liberally illustrated.

This book fits the purpose for which it was written—as a text for a semester course. It is written at a level for beginning students, who are interested in facts rather than opinions, and the scope of the material covered presents a good balance.

GEORGE S. FICHTER

MODERN BIOLOGY, by Truman J. Moon, Paul B. Mann, James H. Otto. Cloth. Pages x plus 698. 15×23.5 cm. 1951. Henry Holt and Company, Inc., New York. Price $3.96.

Modern Biology is a complete revision of the popular and widely used *Biology*, by Moon and Mann. This new edition was prepared by James H. Otto, who is head of the Science Department in George Washington High School in Indianapolis, Indiana. The book has been prepared specifically for use in the secondary schools and for students encountering the field of biology for the first time. Sentences and paragraphs are short, and new words are called out in boldface type. Each of these words also appears in the glossary. The book contains eleven units: The Scientific Study of Living Things, The Relationship of Living Things, The Biology of Plant Life, How Plants Affect Our Lives, The Microscopic World of Life, Simpler Forms of Animal Life, Animals with Backbones, How Biology Applies to Ourselves, Biology and the Problems of Disease, Like Begets Like—the Biology of Heredity, and Safeguarding Our Natural Heritage. Each chapter is concluded by a summary of the chapter's contents, a series of questions, and a list of suggestions for experimentation and application of the knowledge acquired. There are numerous and excellent illustrations. This book will surely be accepted in hundreds of other schools to add to the hundreds which already use it.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

ON THE ORIGIN OF SPECIES, by Charles Darwin. Cloth. Pages xx plus 426. 10.5×16.5 cm. 1951. Philosophical Library, New York. Price $3.75.

Nearly a century has passed since Darwin's ON THE ORIGIN OF SPECIES first appeared in print, an edition of 1250 copies published on November 24, 1859. Since then, scarcely a year has passed without new editions, but this, according to the publishers, is the first reprint of the First Edition, the only changes being in punctuation. Despite the great awareness to the book, not many people really understand Darwin's "theory," for they have learned mostly from talking about it and hearing it talked about. This book is an opportunity to examine the original and to find out why, in 1859, ON THE ORIGIN OF SPECIES was discussed the world over. It is an opportunity to *read* Darwin, unbent and unstretched to suit the opinions of someone else. Since Darwin's time, of course, much research has been done in the field of evolution, and Darwin's work is now outdated. But it cannot be denied that ON THE ORIGIN OF SPECIES was the most powerful single force in bringing about this surge of study and examination of life's processes. It is a science classic, and well worth anyone's reading.

GEORGE S. FICHTER
Miami University
Oxford, Ohio

RADIATION MONITORING IN ATOMIC DEFENSE by Dwight E. Gray, *Chief, Navy Research Section, Library of Congress* and John H. Martens, *Technical Information Service, Atomic Energy Commission.* Pages iv+122. D. Van Nostrand 1951. $2.00.

"This is a specific, how-to-do-it book, written for everyone concerned with the measurement of atomic radiation." It is based on the radiological plans and techniques developed by the Federal Civil Defense Administration and the Atomic Energy Commission. It is in two parts. Part One entitled ***Background Information*** discusses the fundamentals of atomic energy, nuclear radiation, radiation hazards. Part Two—***Instruments and Equipment,*** describes the construction and characteristics of radiation detection devices and their operation, use, and maintenance.

If need for this knowledge and skill in the use of it (much of our knowledge is unused!) ever arises it would be well for every adult to be able to act intelligently—which is what most people cannot do in moments of catastrophic emergency. This book should contribute much to everyone's welfare.

The authors are eminently well-equipped and in so brief a recitation have done a commendable job. The short bibliography is excellently chosen. The investment of two dollars will make every reader substantially informed although it is hoped that need for this kind of knowledge never arises.

JULIUS SUMNER MILLER
Dillard University
New Orleans, Louisiana

BORDERLANDS OF SCIENCE, by Alfred Still. Pages ix+424. Philosophical Library. $3.75.

If a "scientific" man wishes to bring upon himself the wrath and despite of the "scientific" world and to run the risk of being treated with contempt and of having his reputation besmirched with epithet he need do but one thing, to wit, show an interest in the "unscientific." What distinguishes the "scientific" from the "unscientific" is not now ***exactly*** clear. There is a host of borderland phenomena which scientists shy away from and which lend themselves to neither logical deductive argument nor experimental inquiry in the usual sense. Such matters as the divining rod, levitation, clairvoyance, telepathy, faith healing—these are not considered scientific matters for the reason, ***I believe,*** that scientists underestimate their own ignorance! (Heresy!!). It is time we admit, I honestly feel, that our "explanations" of even certain standard natural phenomena are at best only descriptions in terms we are not always sure of.

This small volume is exciting to read. Mr. Still first shows the evolution of ***reason*** in matters that were once ***belief,*** and treats such classical cases as Copernicus and Galileo. He then turns to those phenomena (some of which are mentioned above) for which the "scientist" either fails to provide an "explanation" or what is worse, will not bring himself around to look for one. Much of what Mr. Still reports ***sounds*** like hocus-pocus and the performers loom large as tricksters and cheats. But how much do we really know? Mr. Still classically puts it:

"The monumental conceit of intellectual man probably accounts for the fact that some philosophers and many scientists have assumed the prerogative to deny the existence of what they cannot understand. Since ignorance rather than knowledge habitually denies whatever is unfamiliar, it is not unreasonable to assume that if the man of science had a less exalted opinion of his own talents and achievements, he would be more willing to investigate such borderline subjects as the mysterious art of the water-diviners. The scientist has been accused of being chary of overstepping certain recognized boundaries, because he fears to discover new knowledge which might disturb and perhaps upset his well established and generally accepted theories. This suggests a lack of courage, which is far from being a failing of the true scientist. A more charitable explanation would be that the scientist constantly overlooks what he no longer denies, namely that his theories, based on experimental findings, do not inherently possess an absolute standard of truth; they are merely guesses or approximations,

to be held tentatively until disproved by further experimentation. The scientist would be more broadminded and less contemptuous of the dreamer or mystic if he always remembered that what he confidently regards as the truth is little more than a zealously cherished opinion."

Every chapter has an excellent bibliography and the documentation is scholarly. How much one wishes to "believe" is his own business, obviously, but scientific men should at least show a bit more grace.

JULIUS SUMNER MILLER

MODERN PHYSICS, by Charles E. Dull, *Late Head of Science Department, West Side High School, Newark, New Jersey;* H. Clark Metcalfe, *Science Department, Brentwood High School, Pittsburgh, Pennsylvania;* and William O. Brooks, *Science Department, Technical High School, Springfield, Massachusetts.* Cloth. Pages x+609+xxxi. 15×23.5 cm. 1951. Henry Holt and Company, 257 Fourth Avenue, New York 10, N. Y. Price $3.48.

As nearly as I can recall I encountered my first formal physics in a book by Dull all of 30 years ago! The author's name is a classic in this quarter. With his associates in authorship he has again produced an enviable elementary text.

The method of approach in this edition follows the earlier pattern:

"1. The topic is stated or a question is raised.
2. Some incident with which the student is familiar is used as an introduction.
3. The physical principle is then discussed or explained in language simple enough for a beginner to understand.
4. The way in which the principle is utilized is shown by the use of one or more applications."

This device is pedagogically and instructionally unexcelled for the beginner' The exposition is a model of clarity. The physics is unassailably sound. There are many line drawings, all excellent instructional devices. Many excellent photographs represent applications. Human interest is aroused by historical reference. There is an abundance of excellent problems.

For those who know Dull (*et alii*) no word of mine is necessary. Those who do not should look into it.

JULIUS SUMNER MILLER

BASIC SCIENCE, by J. Darrell Barnard, *Professor of Education, School of Education, New York University, New York City,* and Lon Edwards, *Chairman, Physical Sciences, Danbury State Teachers College, Danbury, Connecticut,* Cloth. Pages vii+631. 15.5×23 cm. 1951. The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y.

This general science textbook appears to be written for the eighth or ninth grade. Thirty-one chapters embracing 13 units cover the following major headings: the earth, the universe, radiant energy, electricity, heat, weather and climate, health, living things, conservation, work and power, transportation and communication, materials of construction. The type is in double column format. There are many excellent illustrations, some three-dimensional, and a goodly number of photographs. The chapter summaries, pupil activities, and science problems at the end of each unit are very good. There is a terrific amount of science in this book, and I only wonder how much of it a beginner could assimilate in one year.

The major weakness appears to me to lie in the total avoidance of mathematics. There are no symbols, no equations, no formulas—the very blood of matters scientific is left out. I have elsewhere pointed up the inadvisability of such pedagogy, for the intelligent citizen must now be able to read the scientist's language, and the sooner he comes to it the better off he will be. School kids must be brought back to mathematics!

This is a good book, however, and a good teacher could accomplish a lot with it.

JULIUS SUMNER MILLER